

A Showcase of Visualization Approaches for Military Decision Makers

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ABSTRACT

Military command and control systems use a wealth of visualization techniques that are applied to a variety of application domains, including Command and Control, Intelligence, Logistics and Information Operations. Recognizing this variety, the TTCP C3I Action Group on Information Visualization has conducted a survey of visualization techniques and approaches used in allied command and control systems or being examined as applied R&D activities. A knowledge-based of these techniques – C3I-Vis – has been developed. A presentation of some of the showcased examples contained in C3I-Vis is proposed as a way of stimulating discussion for the workshop. The presentation will highlight good examples of current practices and state of the art approaches, including visual approaches, information representations, user interaction and customization.

1.0 INTRODUCTION

The Revolution in Military Affairs has moved to centre stage the requirement for information dominance in the joint battlespace. It is predicted that the greatest change in the conduct of future military operations will be the result of the application of information technology to military command and control. With this increased complexity, the need for good Situation Awareness is paramount.

When considering the Cognitive Hierarchy of Information, where data evolves into information, knowledge and understanding, future command and control systems should provide the user with an increased degree of situation awareness so that decision-making is eased. The ultimate aim is to provide Battlefield Visualization, whereby the Commanders develop a clear understanding of their current state with relation to the adversary and the environment, envision a desired end state and then subsequently visualize the sequence of activity that will move their assets from the current state to the end state.

Military command and control systems use a wealth of visualization techniques that are applied to a variety of application domains, including Command and Control, Intelligence, Logistics and Information Operations. Recognizing this variety, the TTCP C3I Action Group on Information Visualization (AG-3) has conducted a survey of visualization techniques and approaches used in allied command and control systems or being examined as applied R&D activities [AG-3, 2002]. A knowledge base of these techniques – C3I-Vis – has

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been developed. It contains in excess of 110 C3I Visualization approaches and over 240 showcase examples (screen shots, video clips), each characterized in terms of the domain contexts, the descriptive aspects and the visualization approaches.

A presentation of some of the showcased examples contained in C3I-Vis is proposed as a way of stimulating discussion for the workshop. The presentation will highlight good examples of current practices and state of the art approaches, including visual approaches, information representations and user interaction.

The presentation first summarizes the Reference Model developed by AG-3, then present and discusses visualization approaches with multiple examples. Finally a summary of significant visualization concepts is provided.

2.0 RM-Vis

A wide range of visualization tools and approaches are already used in the C3I domain. However, there remains vast potential for new and improved applications of information visualization to enhance C3I functions. Such applications should capitalize on the many new approaches and tools being developed by various Defence projects, research organizations, and industry. AG-3 was formed to develop a program of work which would result in a better understanding of how computer-based visualization is and could be applied in C3I.

A Reference Model framework for the application of Visualization approaches (RM-Vis) was defined to support the characterization, identification and showcasing of visualization approaches in the C3I domain. This framework has been used to characterize visualization solutions in terms of their context of use, the representation and presentation techniques used, and key features of tool support provided such as types of user interactions and deployment support.

As shown in Figure 1, RM-Vis has three key dimensions:

- The **Domain Context** is a model that defines the focus for the application of visualization approaches i.e. *where* visualization approaches will be applied, *who* will be supported, and *why* it is needed.
- **Descriptive Aspects** (DA) define what needs to be described for particular domain contexts. For example, DAs could be defined in terms of the various elements (or things) that are of importance, the relationships between those elements and particular attributes that describe the elements and relationships.
- The **Visualization Approach** dimension defines how the required information can be provided through computer-based visualization. Approaches are characterized in terms of the visual representations used (e.g. graphs, charts, maps), visual enhancements (e.g. use of overlays, distortion, animation), interaction (direct manipulation, drag and drop, haptic techniques etc), and deployment which includes the computing environment (display devices, COTS software) and advanced deployment techniques such as intelligent user support and enterprise integration.

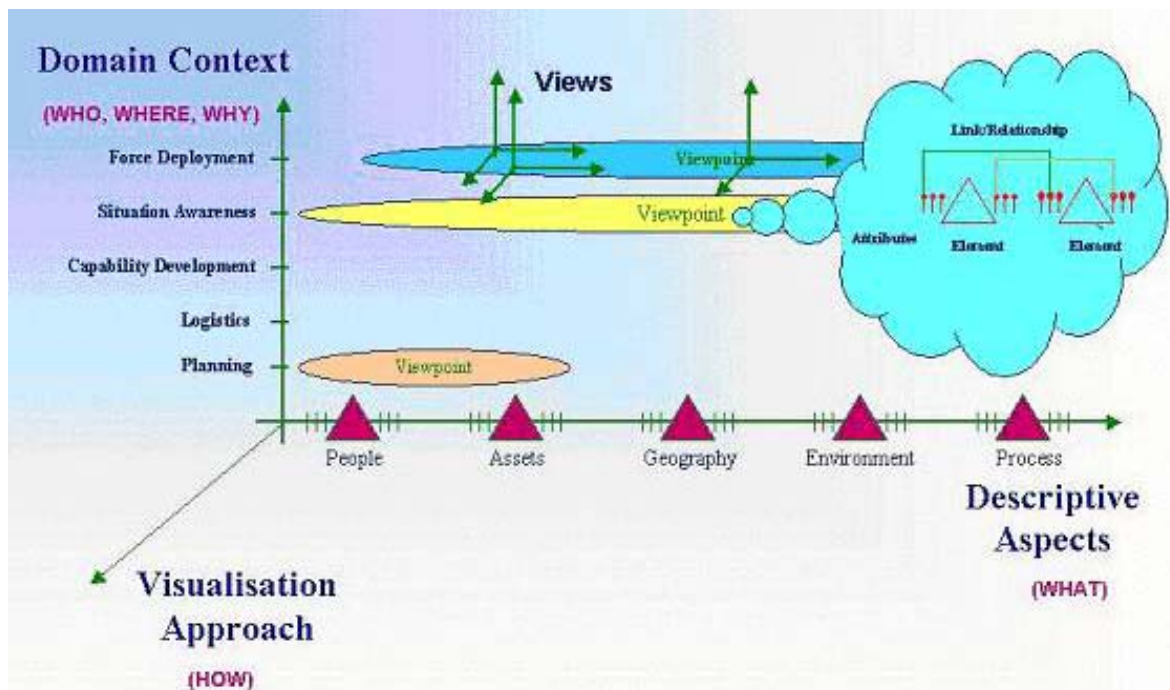


Figure 1: RM-Vis Framework.

A toolkit implementing the key elements the RM-Vis framework was developed to support the characterization, showcasing and querying of visualization approaches within domain usage contexts. Flexible querying mechanisms were implemented to support analysis activities. Two RM-Vis databases were developed using the toolkit: C3I-Vis which characterizes and showcases visualization approaches in C3I domains based on a survey of national programs and G-Vis which characterizes and showcases general approaches in a range of complementary domains such as transport, finance, medicine, entertainment, and engineering.

3.0 VISUALIZATION EXAMPLES

This Section provides significant visualization examples supporting military decision-making.

3.1 Tactical to Strategic Levels of Command

Command and control at the tactical level brings physical constraints that do not apply at the Strategic level of command. These include space limitation, light conditions and operation on the move. An interesting example of a tactical system in terms of visualization is the DoD Force XXI Battle Command, Brigade and Below (FBCB2) System [TRADOC, 2002]. It provides on-the-move, real time and near-real-time battle command information to tactical combat arms, combat support and soldiers, and is integrated in various Army platforms. As shown in Figure 2, the display is customized for use in a vehicle: maximized use of the screen for showing the map, status bar for showing the message queue, alerts and warnings, large function buttons finger or function key activated, forms subdivided in a number of folders and providing menu lists.

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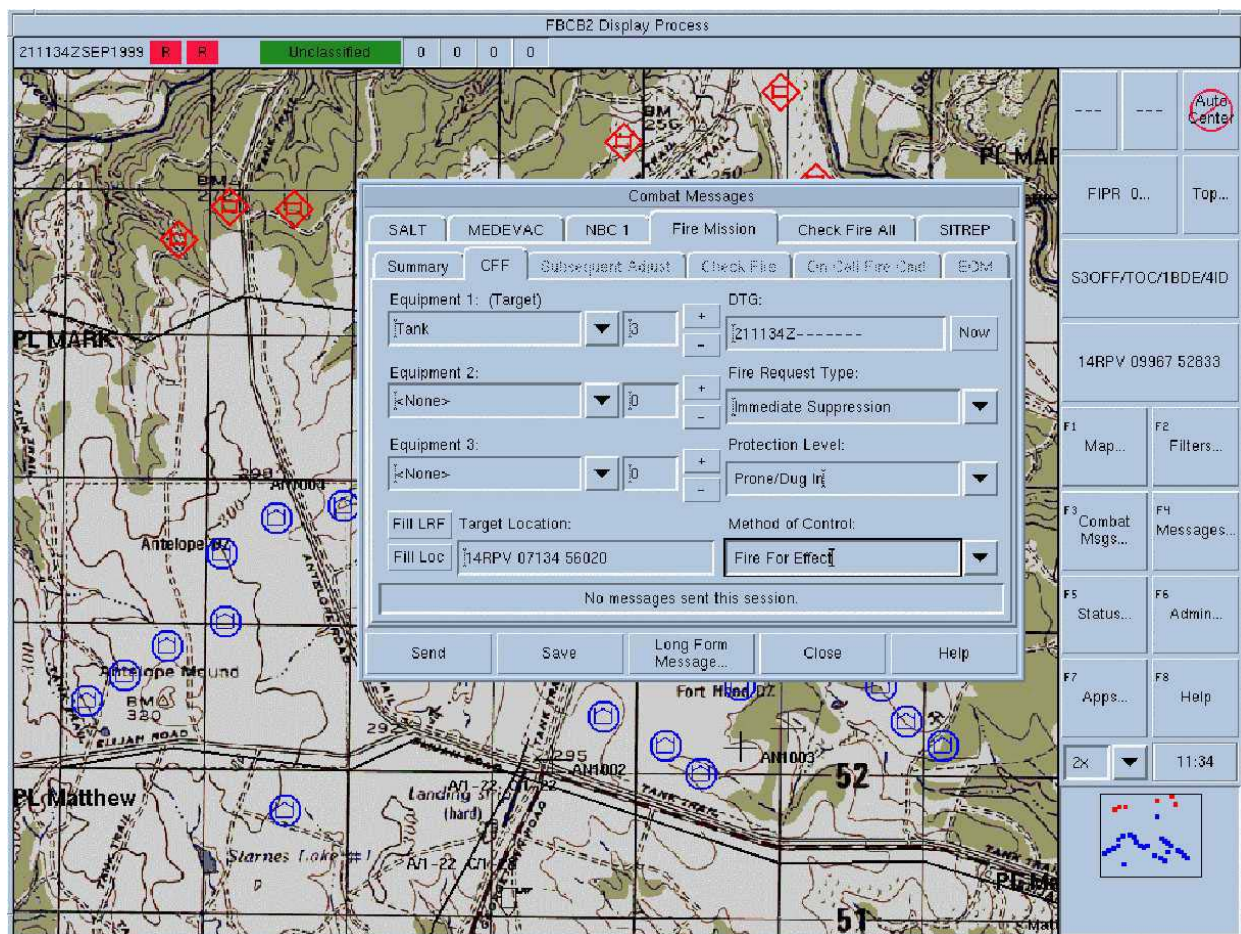


Figure 2: FBCB2 Tactical Display.

At the Strategic level, where there are less physical constraints, one trend is to exploit ‘data wall’ technology. The U.S. Navy at the SPAWAR System Centre is in the process of developing knowledge wall concepts to replace the traditional situation maps that are ubiquitous in modern operations centres (Figure 3). The purpose of the knowledge wall is to foster shared situation awareness, permit continuous updating of the military situation and enhance the senior staff’s ability to interact with supporting information systems.



Figure 3: SPAWAR Knowledge Wall Concepts.

Based on extensive interviews with 30 senior Naval staff officers, the following characteristics were identified as important criteria for developing the knowledge wall [Oonk et al., 2001]:

- Shared situation awareness among its users
- The integration of relevant mission status information
- An intuitive graphical interface
- Consistently formatted information
- The display of mission goals and Commander's Critical Information Requirements
- The display of summary information provided by "anchor desk" or support staff
- The ability to connect and coordinate or collaborate with others at diverse locations
- A flexible configuration that can easily be changed by users
- The ability to drill-down through displayed information for more detail
- Display of information age and reliability

3.2 Visualization Examples from the Command and Control Domain

Typical command and control visualizations have consisted of static, standardized symbols overlaid on terrain, frequently referred to as 'dots on maps'. The following are some examples of where this concept has been advanced. Figure 4 shows an early visualization developed for the CPOF program, called 'Circular Blobs' [Wright & Kapler, 2002]. This has pseudo 3-dimensional terrain with blobs showing force deployment. In this visualization, the thickness of the line represents strength of force and diameter of blobs shows range of weapons.

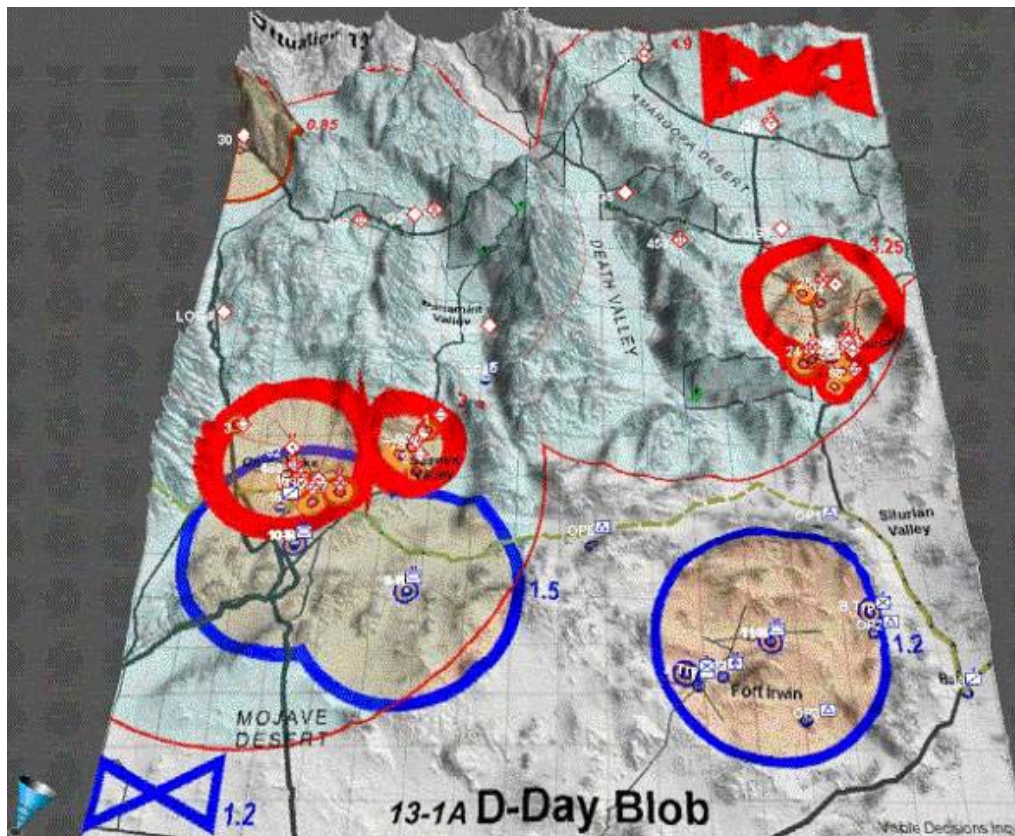


Figure 4: Multi-Dimensional Data Representation Overlaid on Terrain.

The CPOF program has also experimented with shared visualizations to support distributed, collaborative command. The CollabEx system [CollabEx, 2002] was developed to support cross-functional teams – command, intel, fires, manoeuvre – performing tactical planning and execution tasks. The workspace in Figure 5 shows the commander’s viewpoint on the left, and the shared view of another team member on the right. Using freehand sketches, and icons (for planned tasks and enemy forces), each team member creates a view that broadcasts his understanding and approach to the problem. By cycling through these views, it is possible for the commander, and every team member, to maintain topsight over what the entire team thinks. These views also support efficient communication. For example, just as a commander gestures on a subordinate’s paper map, he can use the system’s collaborative pointing and inking tools on any view to convey his intent.

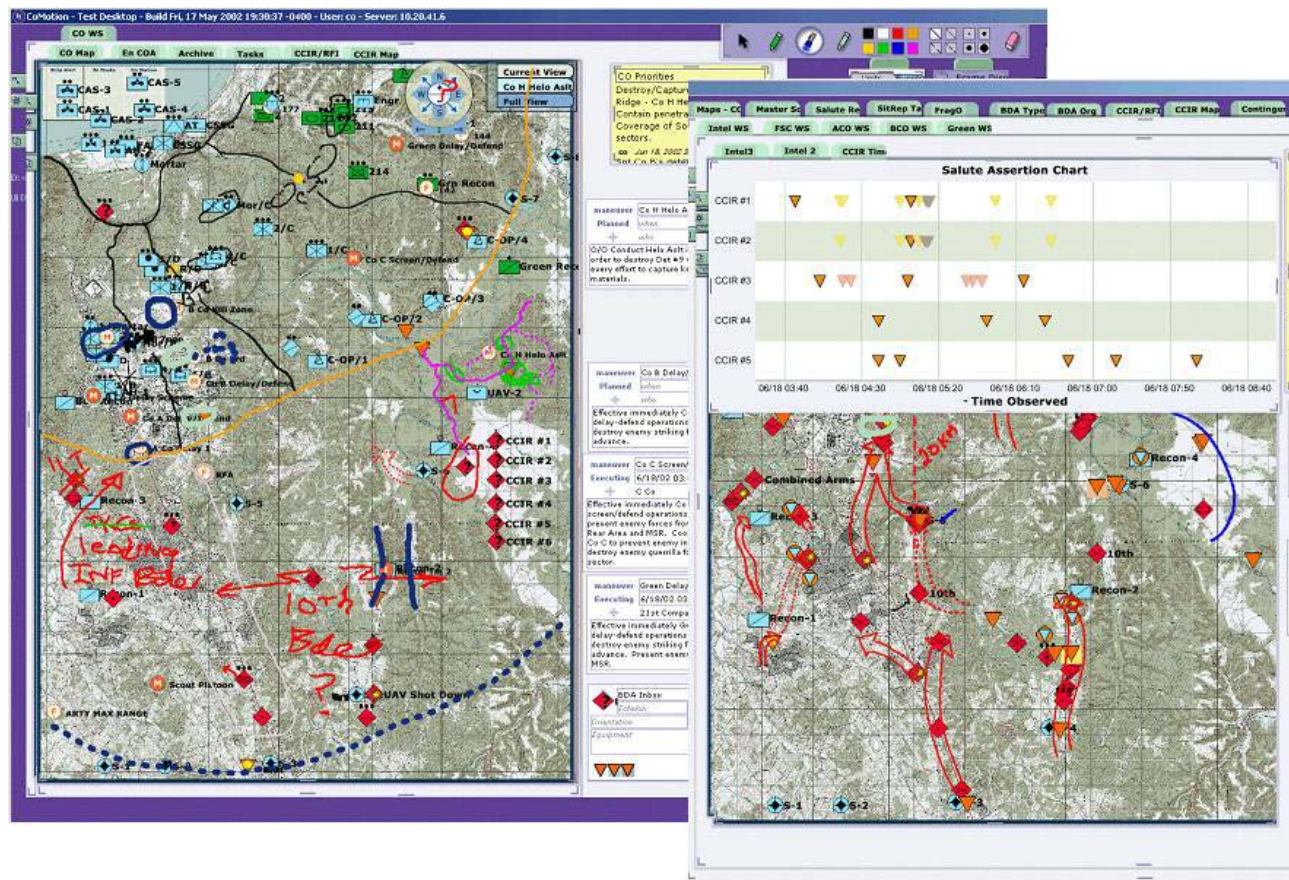


Figure 5: View Coordination and Linking for Collaborative Command Activities.

Other approaches have used flow animations to represent force movements and degrees of uncertainty. Figure 6 shows intuitive battlefield visualization using animated blobs (grouping of entities based on behaviour and status: aggregation and temporal compression involved). This view was created using Virtual GIS at the Army Research Laboratories (USA).

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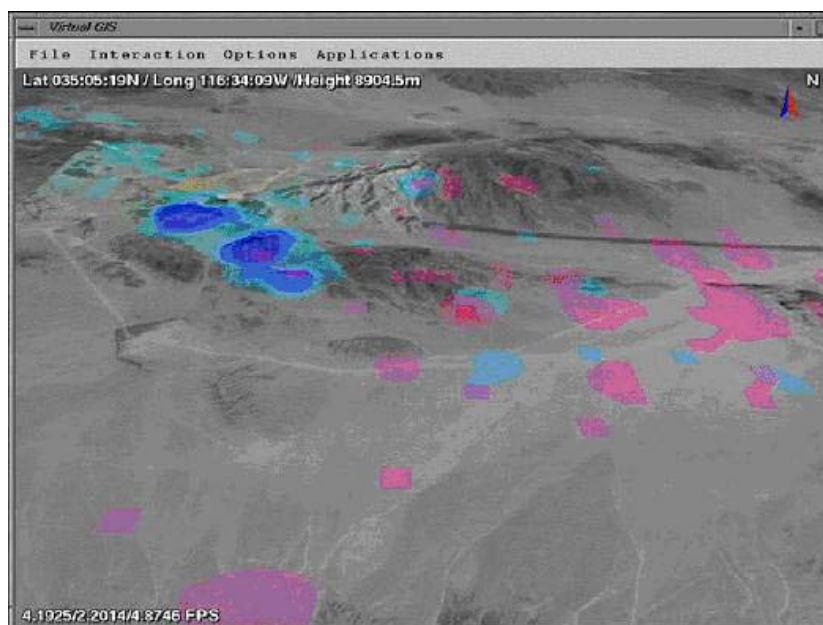


Figure 6: Blobology View of Battlefield.

Virtual Reality concepts for battlespace visualization are being researched at the Naval Research Laboratories (USA). Figure 7 shows an example from the Virtual Reality Responsive Workbench and shows how immersive Virtual Reality could be used to provide visualization and interaction with battlefield information. The visualization shows: Terrain at field resolution, real-time data feeds, icons and overlays of dynamic models on terrain, 3D and 3D stereo approaches.



Figure 7: Planning with the VR Responsive Workbench.

Over the last two years, Enterprise Portal technology and Distributed Collaboration services have become a significant trend in Command and Control Systems. In the coalition context, CINC 21 portal technologies and services are being developed to enable coalition partners to achieve better cross-coalition situational awareness by allowing access to each other's web-based displays and services. For JWID 02, a C2 portal was successfully deployed to support C-CINC 21 experimentation and to demonstrate to the wider JWID audience the value of emerging portal technologies and services (see Figure 8).

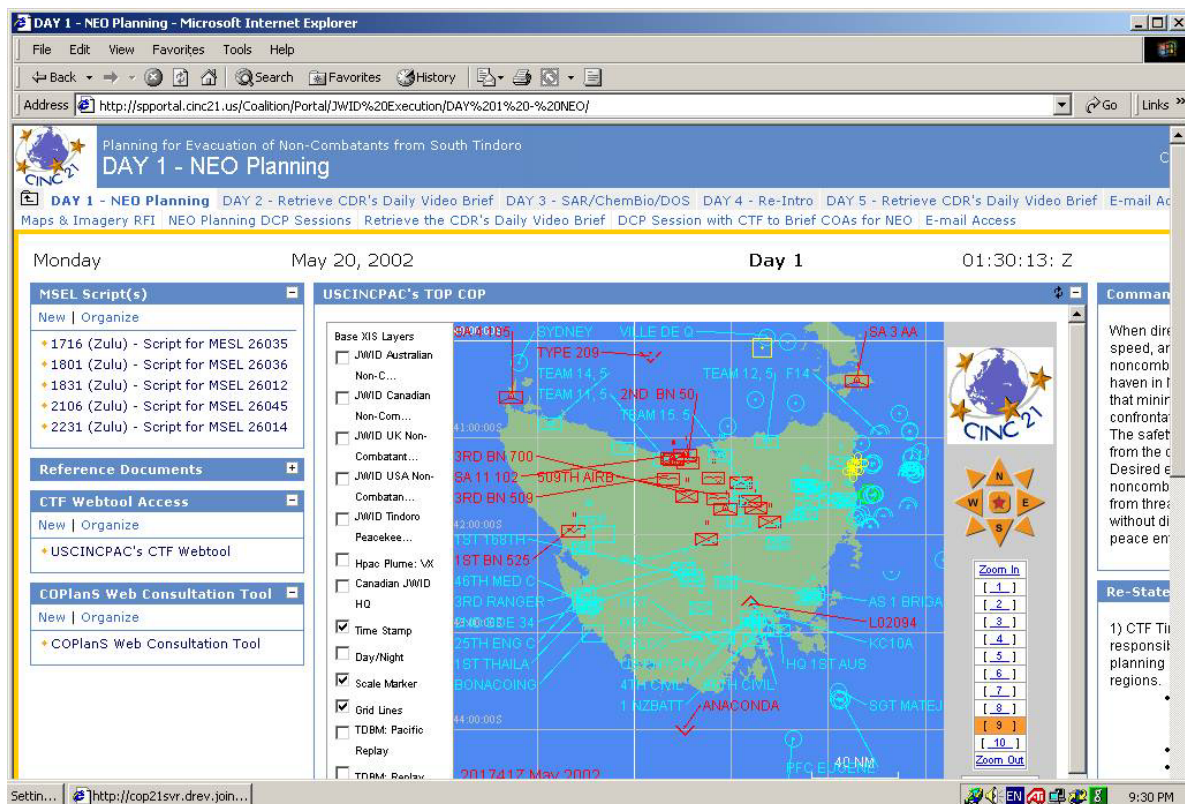


Figure 8: CINC 21 C2 Portal.

As military operations are increasingly performed in urban environments, 3D modeling and visualization capabilities will be required to support commanders in terms of situation awareness and the warfighters in mission rehearsal [Létourneau, 2002]. The production of the models must support an incremental development in terms of granularity and realism, and this granularity must correspond to the tasks to be performed. Figure 9 shows a model of Quebec City that was produced in the context of the American Summit in April 2001.



Figure 9: 3D Urban Model of Quebec City.

3.3 Visualization Examples from the Intelligence Domain

The intelligence domain has used similar approaches to the command and control domain but with more emphasis on the visualization of abstract information (from multiple sources) and relationships overlaid on geomatic representations and the ability to have linked and coordinated views on the display real estate. For example, the All Source Intelligence Prototype (ASIP) from Canada shows the use of geomatic representations with overlaid information. The ASIP is a Canadian command and control prototype system aimed at exploring and demonstrating functions for the Intelligence cell. One of its component is the Situation Map application that provides a digital map-based interface, point-and-click and drag and drop user interface, multiple overlays, military map symbology (NATO military symbology standard APP-6(A) and MIL-STD 2525B), map symbol editor, graphical reasoning (tracking, merging, aggregating, link analysis), map symbol palette, annotation, briefing handling. A major contribution of ASIP is in the management of overlays and sharing of views through live channels. Figure 10 shows an interesting feature of ASIP with coalition symbology, where an optional representation of MIL-STD 2525B allows showing the different factions in a Coalition Operation with a different colour, for friendly, enemy and neutral forces.

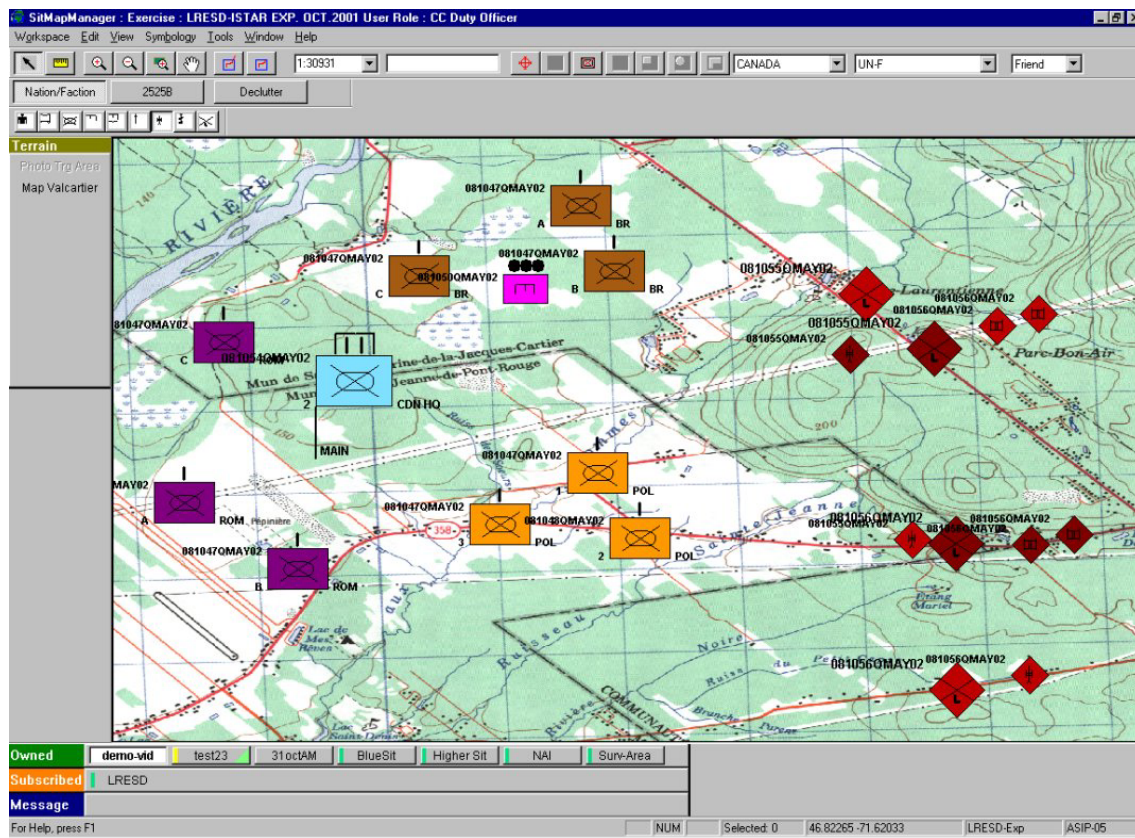


Figure 10: Intelligence View from ASIP.

Sophisticated 3D animated representations have been used in the Intelligence Surveillance and Reconnaissance (ISR) area to represent red and blue asset coverage. Figure 11 shows a view from BattleScape where geometric shapes (conical, spherical, etc) have been used to represent ISR asset coverage. This view also shows the concept of integrating imagery with geographic information. BattleScape is a commercial tool from the USA. It enables recognition of risks and opportunities to assist command of forces. It continuously displays near real time information reported by surveillance and reconnaissance sensors in 2D and 3D with maps, imagery, and terrain. BattleScape interfaces with existing C4ISR processors to create 2D and 3D continuous views of the battlespace, all referenced to digital maps, imagery, and elevation data sets chosen by the Warfighter.

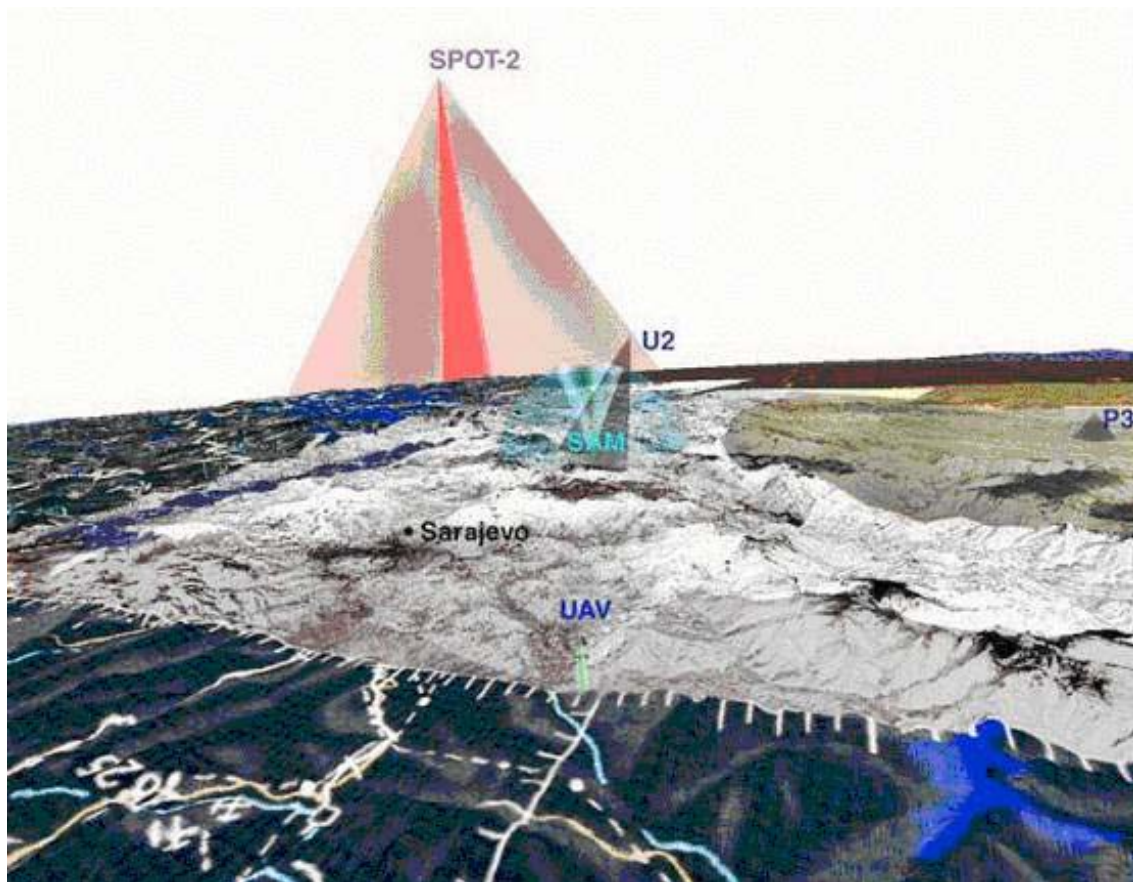


Figure 11: A 3D Intelligence View from Battlescape.

A growing visualization technique for the Intelligence Domain is Link Analysis. This technique is very useful to show relationships between people, organizations, events, incidents, behaviours and locations as shown on Figure 12a taken from the US IntelCenter. The focus of the IntelCenter is on studying terrorist groups and other threat actors and disseminating that information in a timely manner to those who can take action on it. Its primary client base is comprised of military, law enforcement and intelligence agencies in the US and other allied countries around the world [IntelCenter, 2002]. Figure 12b is a subset of *Mapping al-Qaeda v1.0*, a product utilizing link analysis technology to provide visual maps of terrorist networks around the world and to help foster a better understanding of al-Qaeda's operational characteristics and organizational structure.

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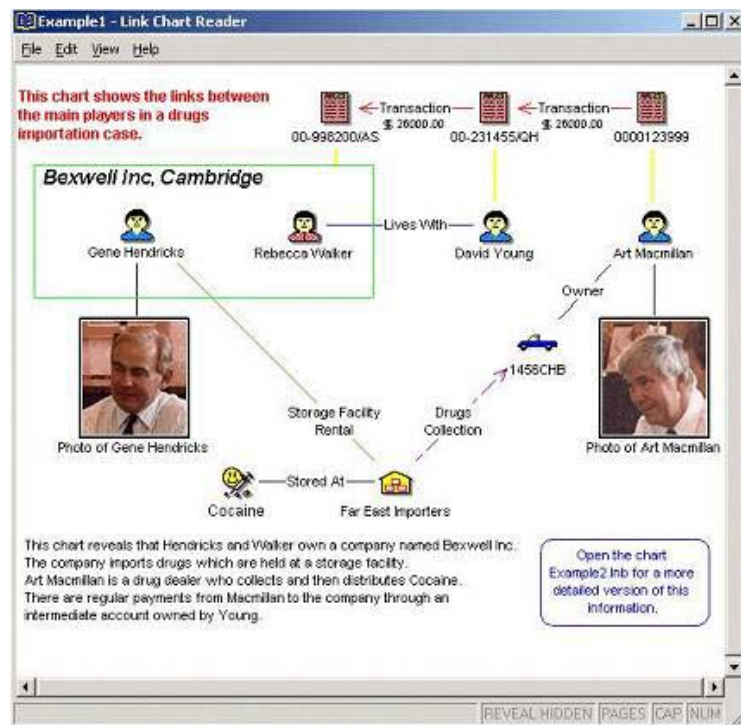


Figure 12a: Link Analysis for Drug Interdiction.

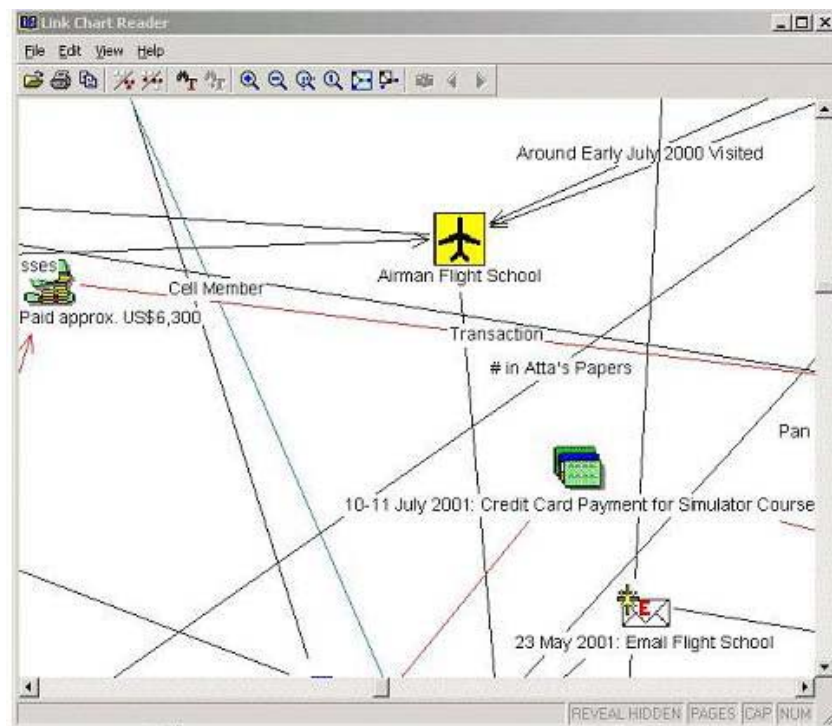


Figure 12b: Link Analysis Applied to the al-Qaeda Network.

3.4 Visualization Examples from the Logistics Domain

In the Logistics domain, resources, assets, inventory, geography, and more importantly, time, process, sequence, status, health and coordination are critical attributes that require integrated visual representations to support logistics activities in dynamic (national and coalition) environments.

The Joint Logistics Advanced Capability Technology Demonstrator (JL ACTD) – Visage represents an approach for coordinating visualizations and analytical tools in data-intensive domains [Roth et al., 1996, Maya, 1997]. It provides techniques for locating, selecting, visualizing, manipulating, and analyzing information. It also provides a user interface for sharing information among other data analysis and presentation tools. Figure 13 shows a screen shot of Visage in action where three linked visual representations (table, map and chart views) are displayed with colour mapping. The example illustrates how an Army analyst, who needs to explore the supply needs of a particular group in an Army organization, uses an outliner table that shows information hierarchically. The analyst starts from a single point in a data network and can drill down or across the hierarchy. Here, he drags a selected set of units from the outliner to a frame that displays its data objects in the form of a bar graph showing the units' supply weight. He can then drag copies of the elements representing these units to yet another frame, this one displaying the data superimposed upon a map. All three displays are coordinated. Users can also drag or copy their analysis displays directly into a briefing slide.

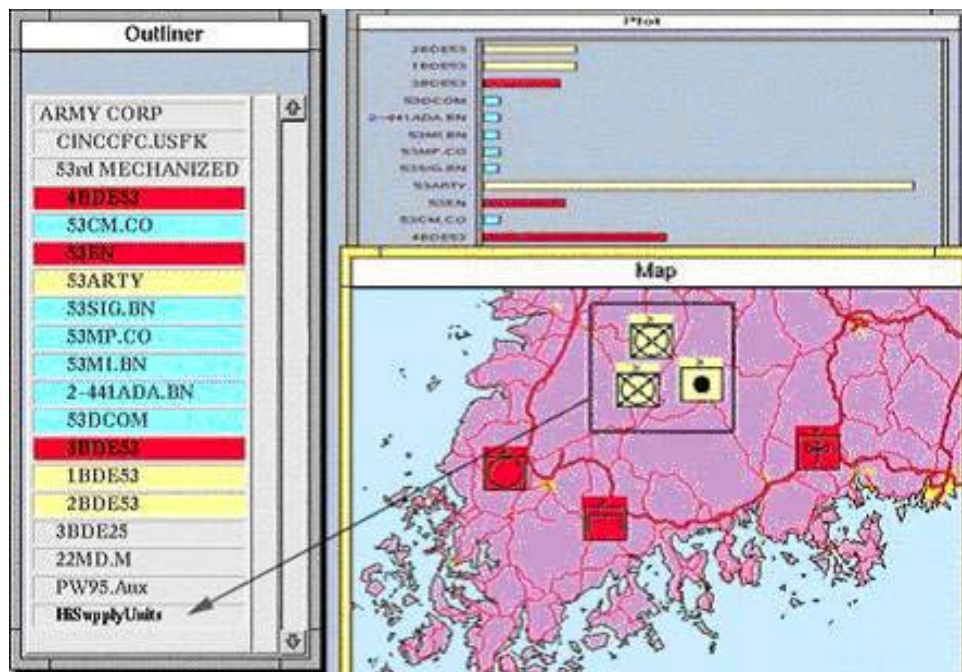


Figure 13: Army Logistics View with JL ACTD Visage.

Another logistics domain tool is the Watchboard tool from the Joint Theatre Logistics (JTL) ACTD [JTL, 2002] shown in Figure 14. One tool allows the comparison of planned vs. actual COAs along abstract dimensions of supportability. Another supports comparison of planned and actual COAs on a coordinated time and geographic visualization called the TimeMap. The TimeMap allows direct re-planning if required changes to the support plan are discovered. JTL's Watchboard tool also monitors critical logistics events, items and

personnel with integrated and linked graphical charts, maps, tables and graphs. This is accomplished, to some extent, through the use of agent technology that periodically queries data sources. All the tools in JTL are built using a data visualization framework which allows interfaces to link directly to an underlying data source. As other JTL tools are used which impact the COA data that is visualized in the Watchboard, the Watchboard's display is updated automatically.

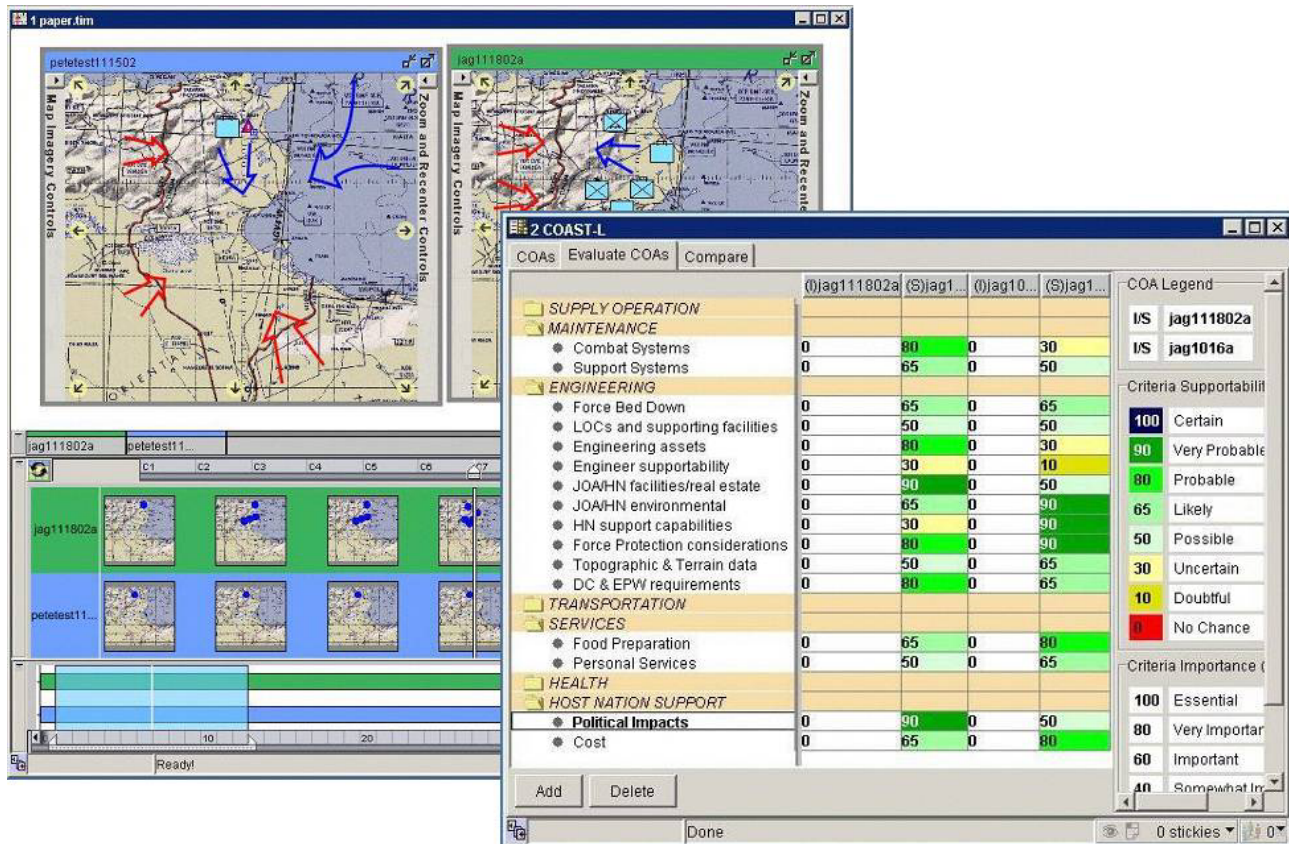


Figure 14: Logistics Views from JTL ACTD Watchboard.

Figure 15 shows an example from Planimate-Belisi that provides animation, drill down into the details of each unit, sub-unit and function as required, drag and drop of icons, map, and the use of distortion to provide a detail view of an area of interest whilst maintaining the context of the overall picture. Planimate – is software designed for constructing dynamic system models and Animated Management Tools, for use in Animated Planning Platforms. Planimate-Belisi is an instance application developed by the Defence Science and Technology Organisation (DSTO) in Australia to address dynamic logistics planning.

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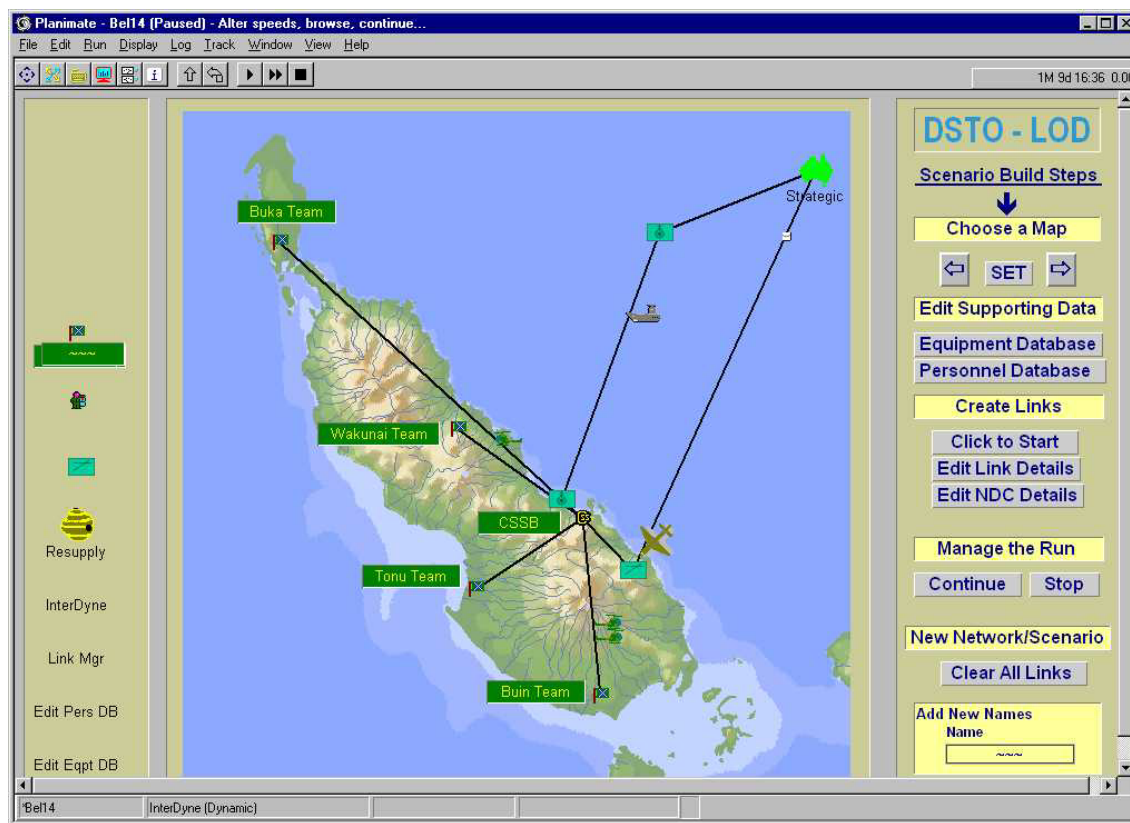


Figure 15: Distorted Logistics View from Planimate Belisi.

Demonstrated during JWID 02, the Canadian COPlanS is an integrated flexible suite of planning, decision-aid and workflow management tools specially designed to support different Military Operations Planning Processes. In particular, it supports the development, analysis and comparison of Courses of Action (COA) using distributed collaboration services, multi-criteria analysis and a number of visual charts (Figure 16). The user is able to assess the various COAs using a number of evaluation criteria. Charts are used to display the evaluation by criterion or globally. Weighting factors can be readjusted graphically.

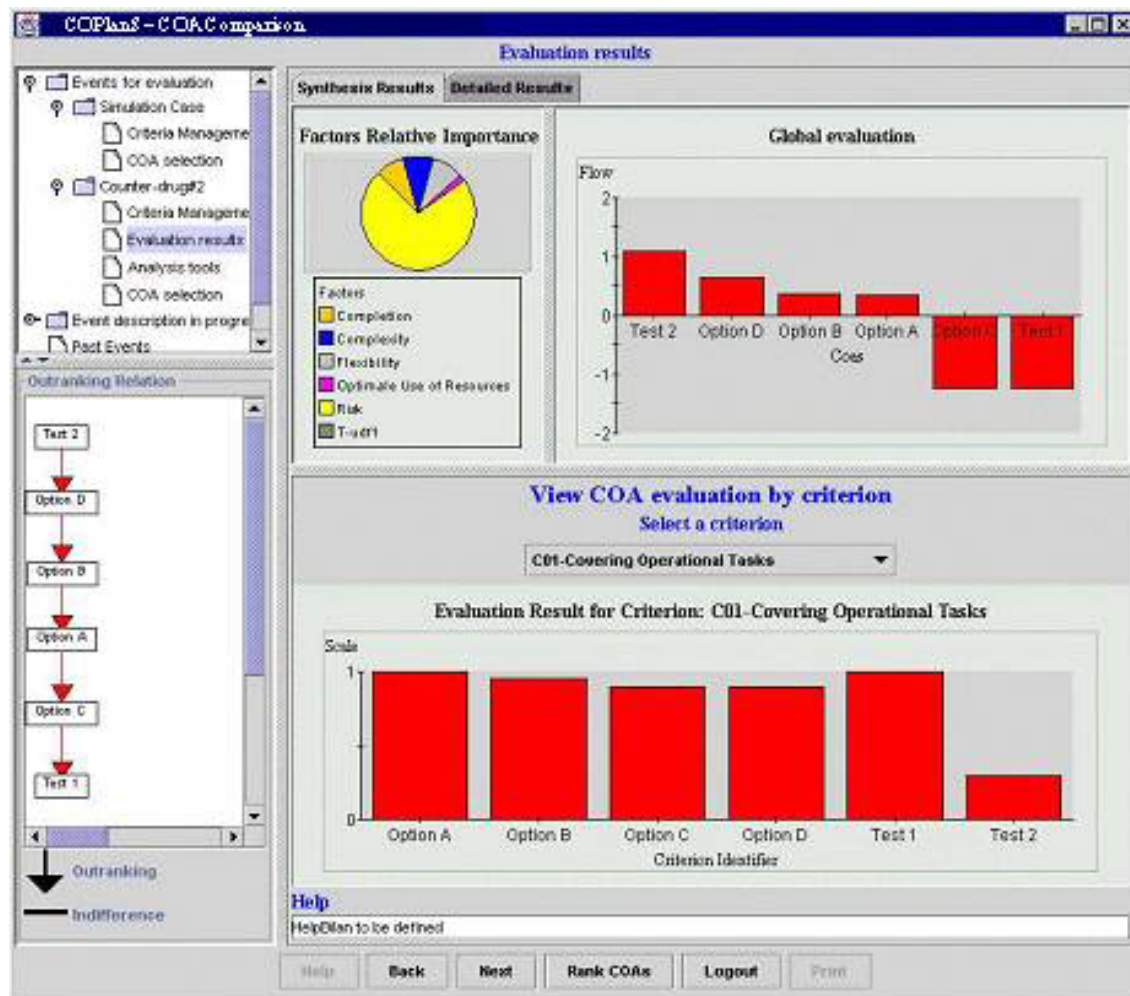


Figure 16: COPlanS Course of Action Comparison.

Canada's Operational Planning Environment and Reference Application (OPERA) is a suite of interrelated tools that provide advanced planning and calculation capabilities. The OPERA folder provides a hierarchical display of OPERA elements and subsequent access to corresponding detailed information. These elements include plans, organizations, equipment and reference documents. Depending on the selected element, the appropriate visualization technique is selected. Hence, as shown on Figure 17, the ORBAT (Order of Battle) Browser allows the display and edition of military organizations through either a tree view or organisation chart view, with full control over the displayed information and the display of associated resources.

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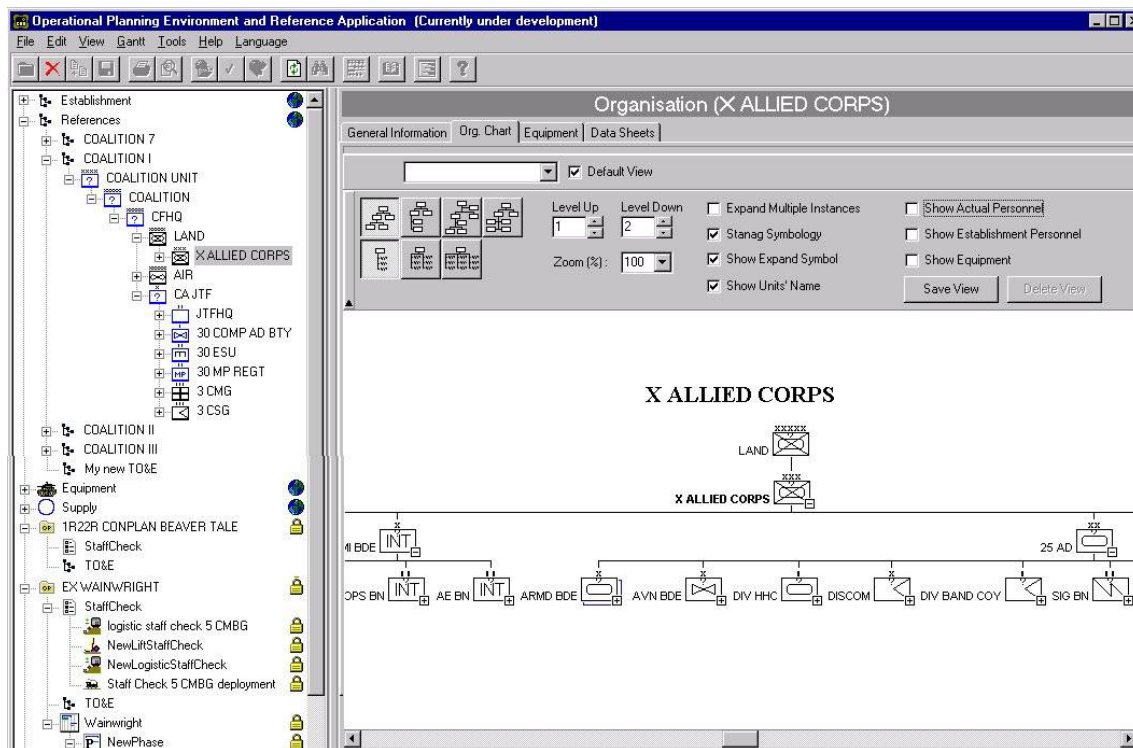


Figure 17: The Operational Planning Environment and Reference Application (OPERA) Orbat Browser.

Chameleon is an approach for developing, capturing and demonstrating command and control concepts using an interactive mock-up. The mock-up is developed in a breadth-first manner using rapid application development tools (i.e. Borland Delphi). It has been used to develop C&C concepts for the Canadian Armed Forces [Gouin, 1997]. Chameleon in Figure 18 illustrates the use of an iconic spreadsheet and colour mapping to help rail embarkation planning. Chameleon has taken the spreadsheet concept further by allowing icons within cells and the characteristics of the icons (i.e., size, shape, colour, etc) to map onto underlying information attributes, the result being a more visually informative spreadsheet.

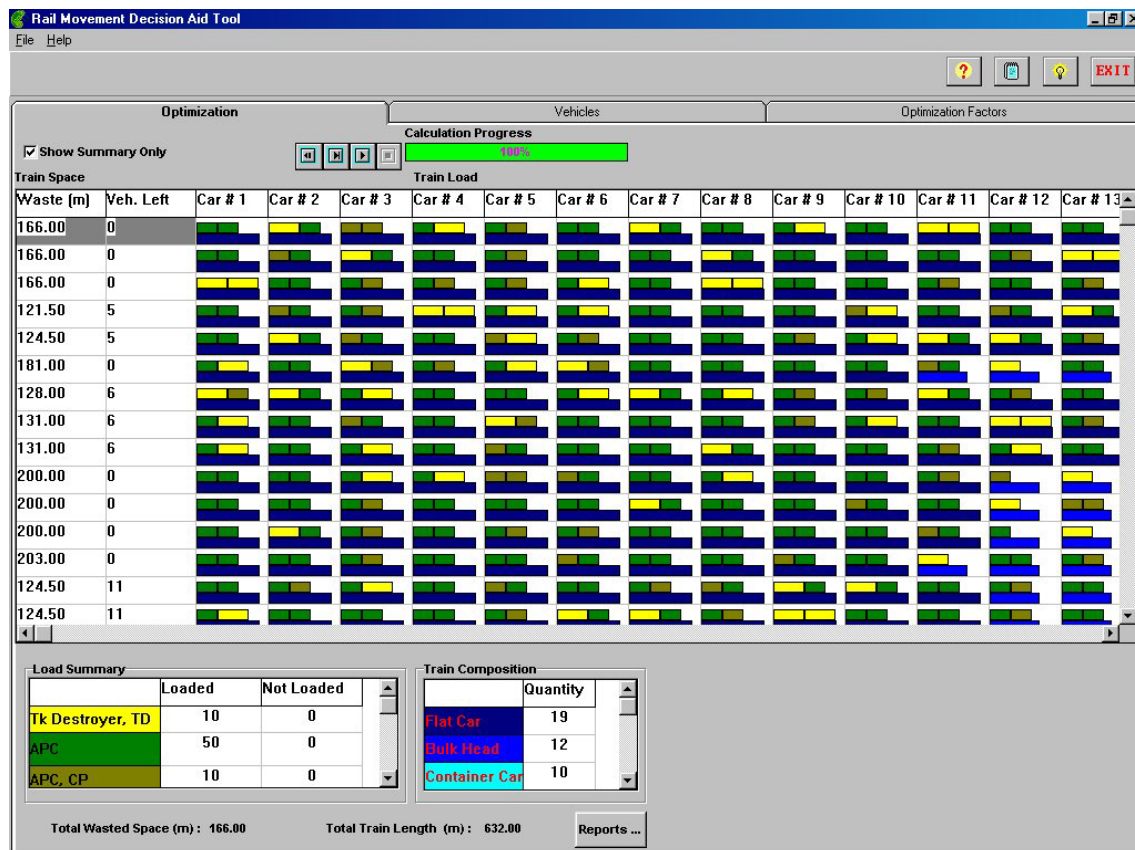


Figure 18: Rail Movement Planner Logistics View from Chameleon.

3.5 Visualization Examples from the Information Operations Domain

The nature of the information operations domain lends itself to the use of abstract information visualization approaches and novel user-to-computer interactions to aid in the exploration and understanding of very large amounts of data/information. The Information Operations domain primarily has focused on information exploration, data/information relationships and trends.

Ironman (a tool from Canada) is a system, which is being developed and used to integrate academic and commercial tools providing network discovery/scanning, intrusion detection and management capabilities [Kuchta, 2000]. Added to these tools are a data visualization environment, modelling, analysis and reasoning tools, and a policy management framework. Ironman is a prototype environment designed to provide interactive management of networks and network components and services. Interaction is provided through a VRML 2.0 3D virtual environment and through additional extended controls such as forms and dialog boxes. Figure 19 presents a view from Ironman, which shows an automated generation of a mapping from five network components (hosts on a LAN) to one of 313 vulnerabilities, which are scanned for by Ballista (a network vulnerability assessment tool). The links between the network components (light blue boxes) and the red, green and yellow boxes represent associations between a specific vulnerability and network component. In this case, the red boxes represent high-risk vulnerabilities, the yellow boxes represent medium risk vulnerabilities and the green boxes represent low risk vulnerabilities.

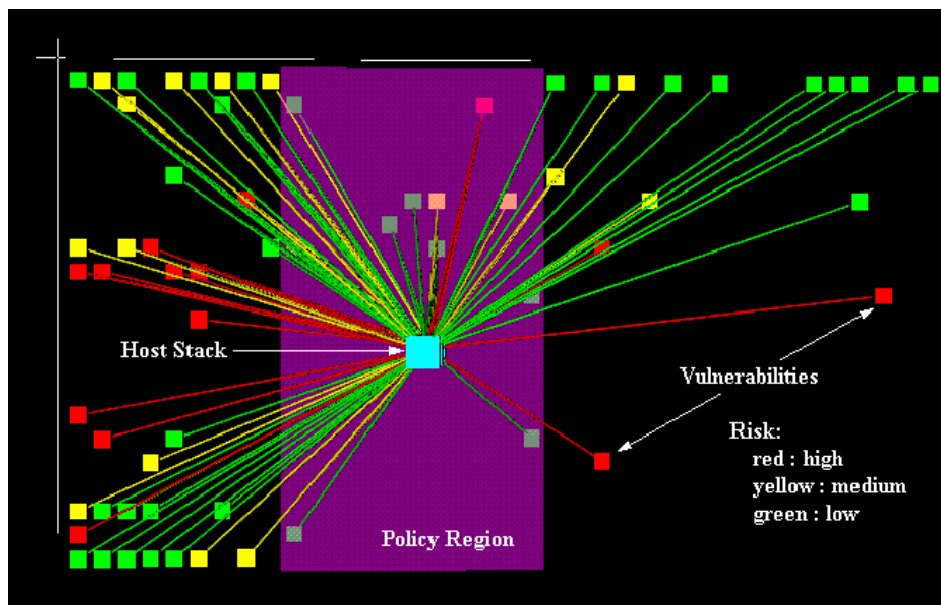


Figure 19: Network Vulnerability View from Ironman.

Shapes Vector is an Australian Defence prototype tool used for the monitoring of very large defence networks. Shapes Vector combines three dimensional visualization techniques with innovative artificial intelligent software agents to patrol and report on wide area network anomalies. Figure 20 provides an example from Shapes Vector, which shows a 3D stereoscopic view of very large networks. Operators interact with the system to determine the nature of anomalies and take action to maintain network security.



Figure 20: Large Network View from Shapes Vector.

The Information Assurance: Automated Intrusion Detection Environment (IA:AIDE) ACTD is a tool from the US Air Force to provide high confidence warning of an Information Warfare (IW) attack [Temin, 1999]. Figure 21 presents an example from IA-AIDE, which shows a composite view that integrates the geographic location of military network sites with information on various classes of intrusion events. Direct manipulation approaches are used to provide specific information on information sources at particular locations.

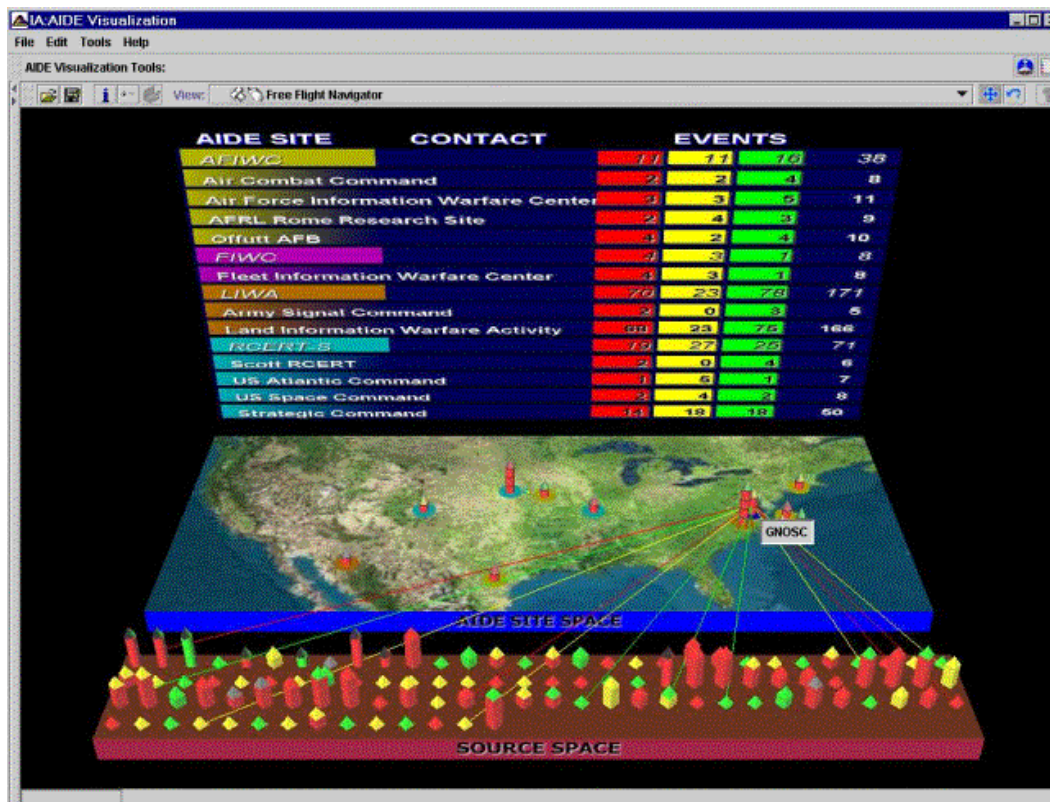


Figure 21: Composite View from IA-AIDE.

4.0 DISCUSSION

This paper has illustrated a number of interesting military visualization examples. Some of them refer to deployed command and control systems while others represent proof of concept prototypes. Although no comprehensive experimentation has been conducted with these systems as part of the AG-3 work, a number of findings can be derived.

Map-based representation is a privileged form of visual representation for C3I applications. Still, the examples contained in the C3I knowledge base show a wide variety of interface design, support for user interaction, symbology. Some of the positive features are:

- Use of 2D or 3D map representations depending on the task and possibility to transition from one mode to another.
- Information content and map scale that is tailored to the user role / task.

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- Use of a meaningful symbology (shapes, colours) including Coalition symbology (different colour for each faction).
- Capability to dim the map background to highlight overlaid information.
- Display of temporal information using traces, playback, blobology.

In terms of non-map-based representations, there is a wide use of Organization Charts, 3D Charts, Gantt charts and an increasing use of dashboards, in particular for Logistics and Planning applications.

The showcased examples used in this paper highlight the adherence to a number of human computer interface principles that provide an intuitive and efficient graphical user interface:

- Interface Design. Careful design of the screen real estate and interface widgets to ensure an efficient interface.
- Outline/Tree Views to present information using a hierarchical representation, with the ability to expand or collapse certain hierarchies selectively.
- Object Explorer widget also to present a hierarchical view of objects, but selecting an object leads to a different visual representation.
- Information Categories. Subdivision of the information into meaningful categories, using sub-areas and tab folders.
- Multimedia information. Use of multimedia (video, imagery, alarms) such as TV feeds, reconnaissance video and collateral imagery to enhance situation awareness.
- Hyperlinks. Use of hyperlinks to provide association between information elements and a capability to drill down into the information.
- Multiple views. Information must be presentable in multiple views.
- Drag and Drop. The user can pass information easily between two applications or tools using drag-and-drop operations.
- Animation. Use of animation to display temporal information, for example to can playback the current situation or to “animate” a plan.

The examples also illustrate significant trends that are occurring in terms of information visualization:

- Collaboration. Users realize the benefits of collaboration tools / services to support collaborative work and the sharing of information.
- Portal Technology. Use of Enterprise Portal technology is a significant trend in providing a common access to information.
- Synchronized views. The use of synchronized views has been shown in a number of research programs.
- Immersive displays. Use of Immersive environments, virtual and augmented reality, and multi-modal interaction are increasingly exploited to provide an enhanced interaction with information.
- Display Devices. A wide variety of display devices such as large screen displays, data / knowledge walls, two/tri panel displays and head mounted-displays are increasingly used.

- Abstract Representation. Significant R&D is being conducted in abstract representations and provides solutions to key threats (e.g. network intrusions, terrorist networks).
- 3D Urban Models. As more and more military operations are taking place in Urban Environments, the use of 3D urban models will improve situation awareness and help in mission rehearsal.
- Coalition operations. The large number of coalition operations impose a need to work towards visualization solutions that provide a coalition shared situation awareness.

5.0 CONCLUSION

This paper illustrates a number of interesting visualization examples extracted from the C3I knowledge based put together by the TTCP C3I Action Group on Information Visualization. These examples highlight a number of novel / efficient visualization concepts addressing the various dimensions of the Visualization Reference Model (RM-Vis): the Domain Context (context of use); the Descriptive Aspects (elements of information) and the Visualization Approach, including the visual representation, visual enhancements and interaction.

Although more experimentation must be conducted for the assessment of visualization solutions in military command and control systems, the C3I visualization database provide a good foundation to share and grow knowledge on visualization.

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A Showcase of Visualization Approaches for Military Decision Makers

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SYMPOSIA DISCUSSION – PAPER NO: 1

Author Name: Mr. Denis Gouin, Defence R&D Canada, Canada

Question:

How can we make use of the database of examples?

Author Response:

There is some difficulty in distribution because is it foundation work. They are in a database, but it is not yet known how broadly they can be distributed.

Question:

Where do these examples fit?

Author Response:

More testing is required.

A Showcase of Visualization Approaches for Military Decision Makers





A Showcase of Visualization Approaches for Military Decision Makers

Denis Gouin
Defence R&D Canada Valcartier, Canada

Peter Evdokiou & Rudi Vernik
Defence Science & Technology Organization, Australia

10 September 2002



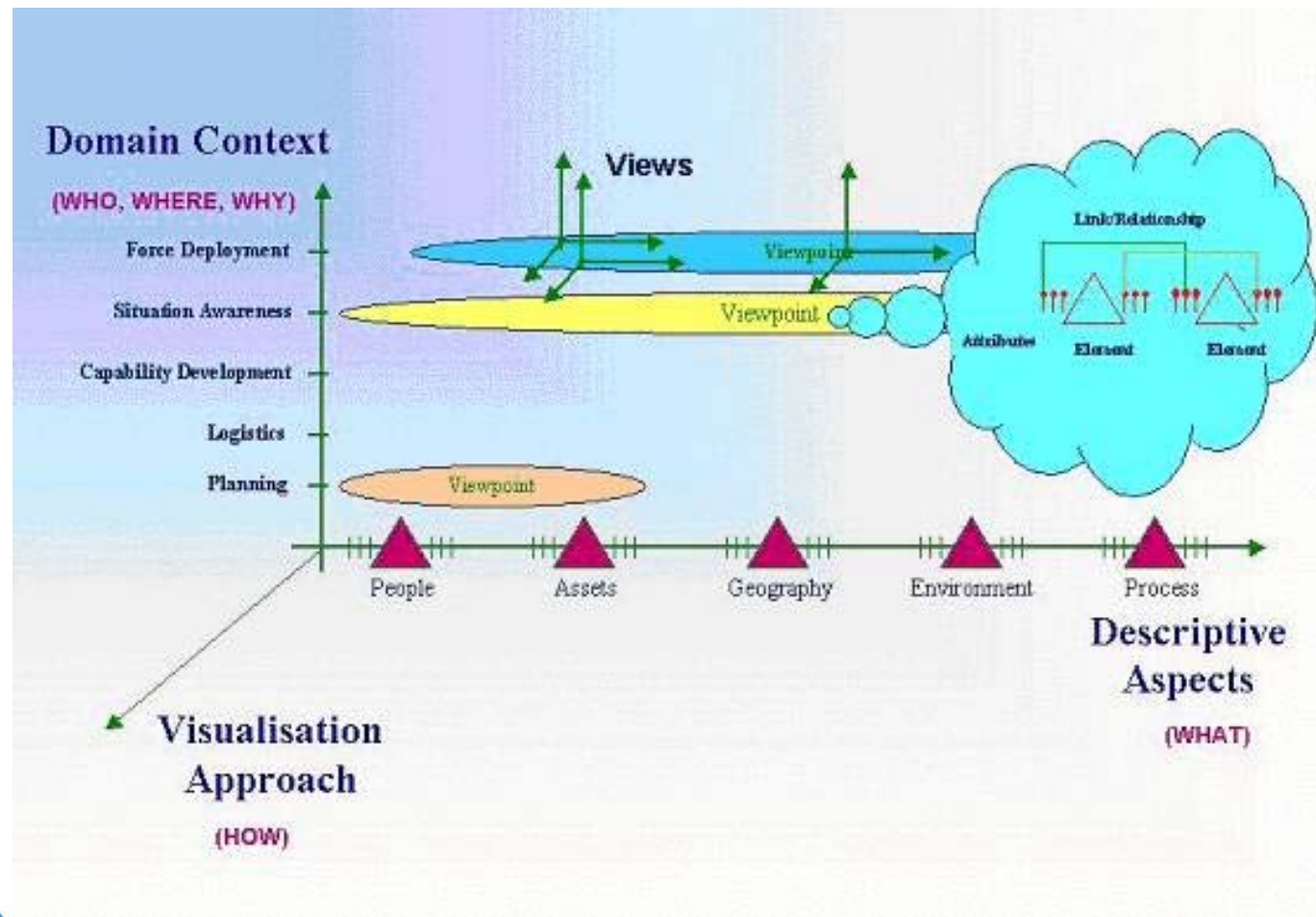
Defence R&D
Canada

R et D pour la défense
Canada

Canada

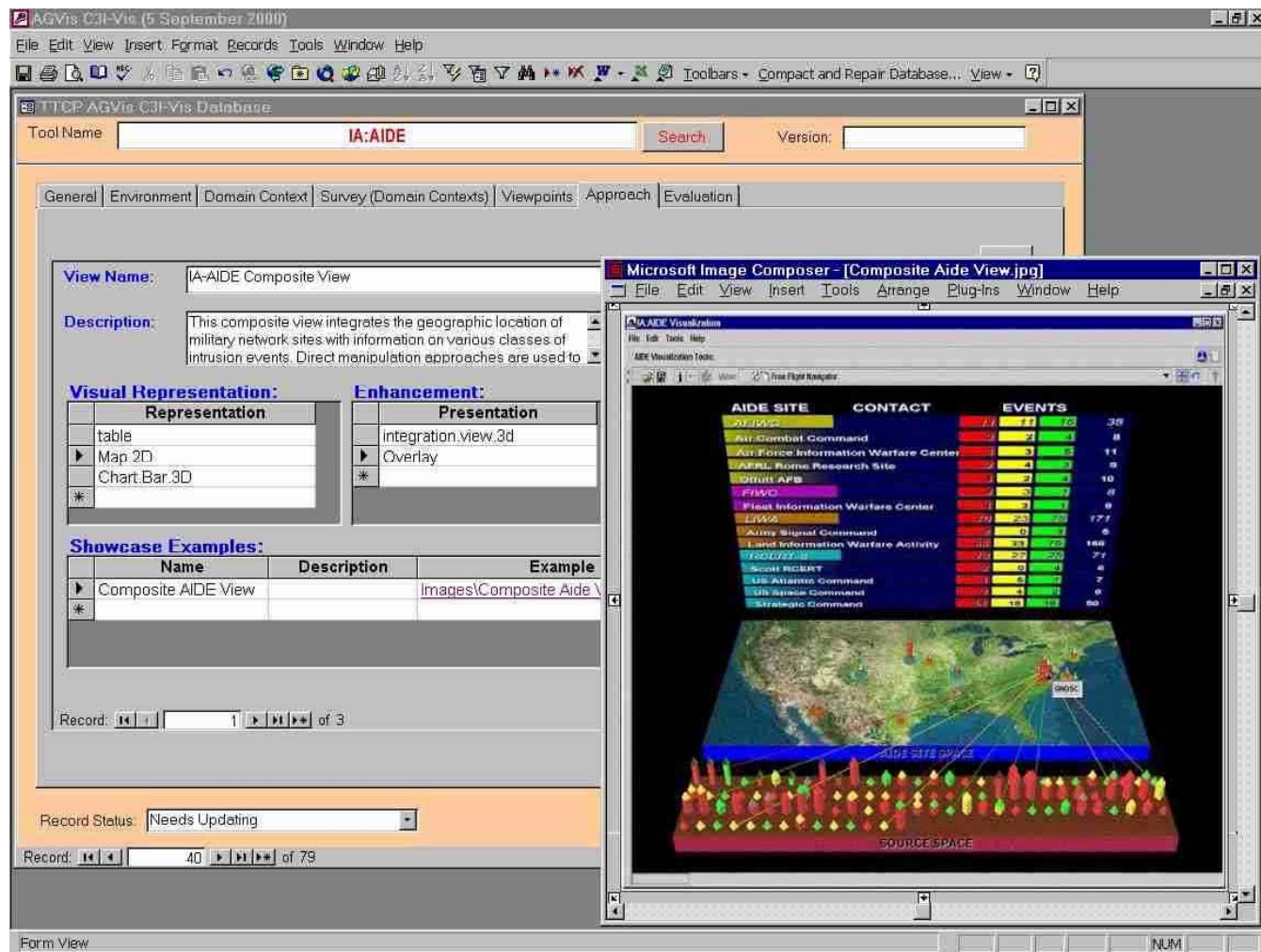


Visualization Reference Model (RM-Vis)





RM-Vis Toolkit

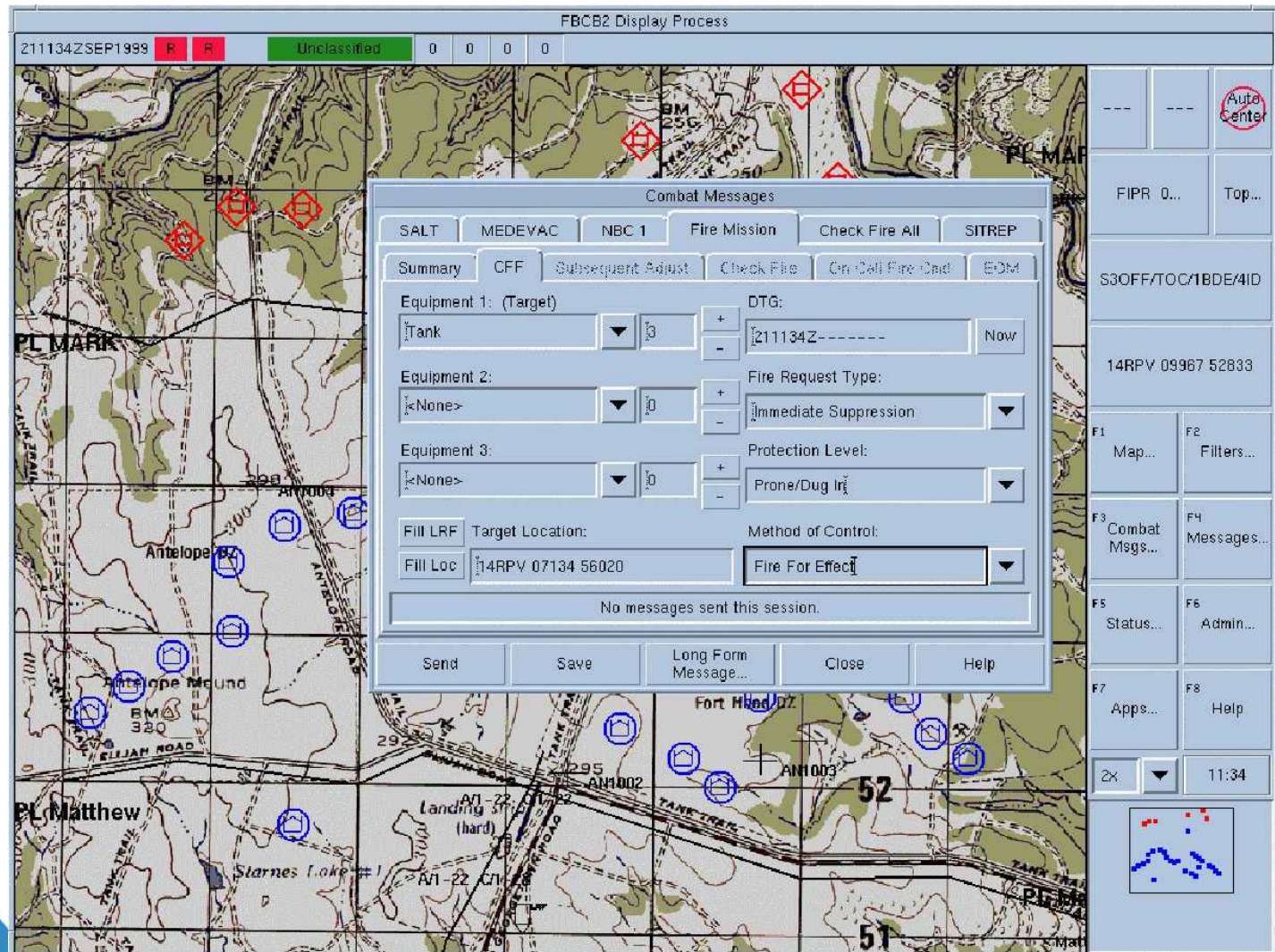




Tactical to Strategic Levels of Command



Tactical Display





Strategic Display (Knowledge Wall)

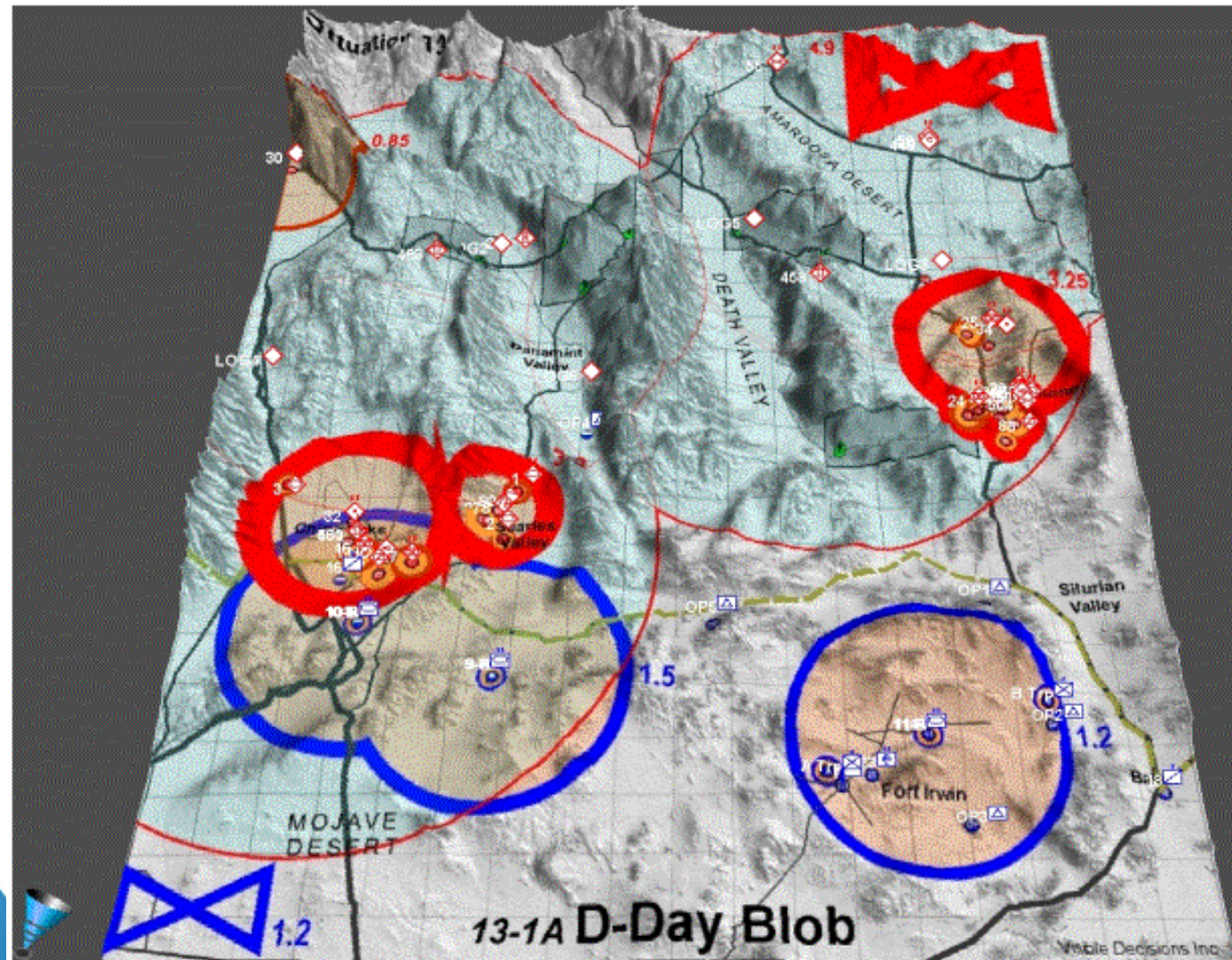




Command and Control Domain

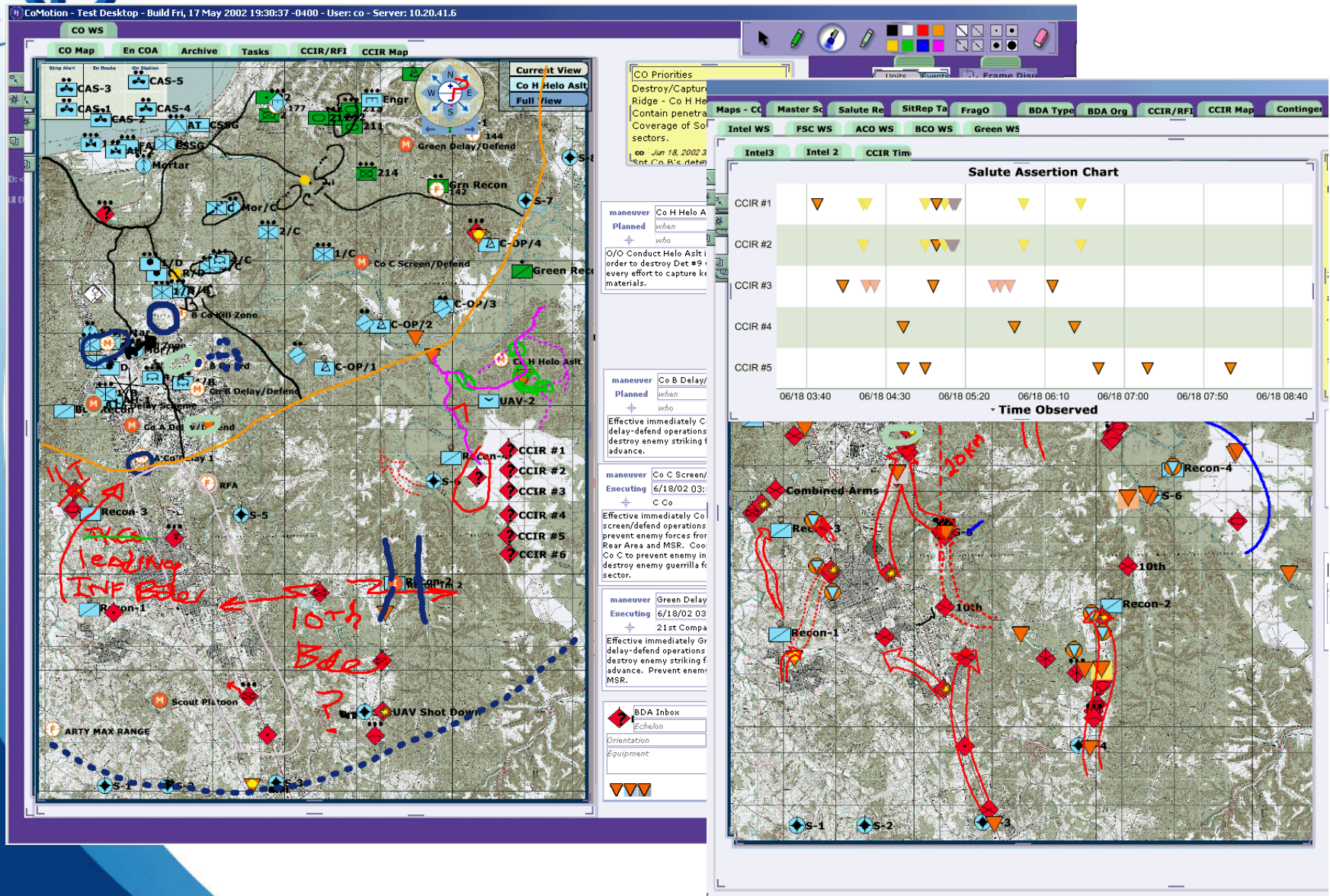


Force Deployment Blobs



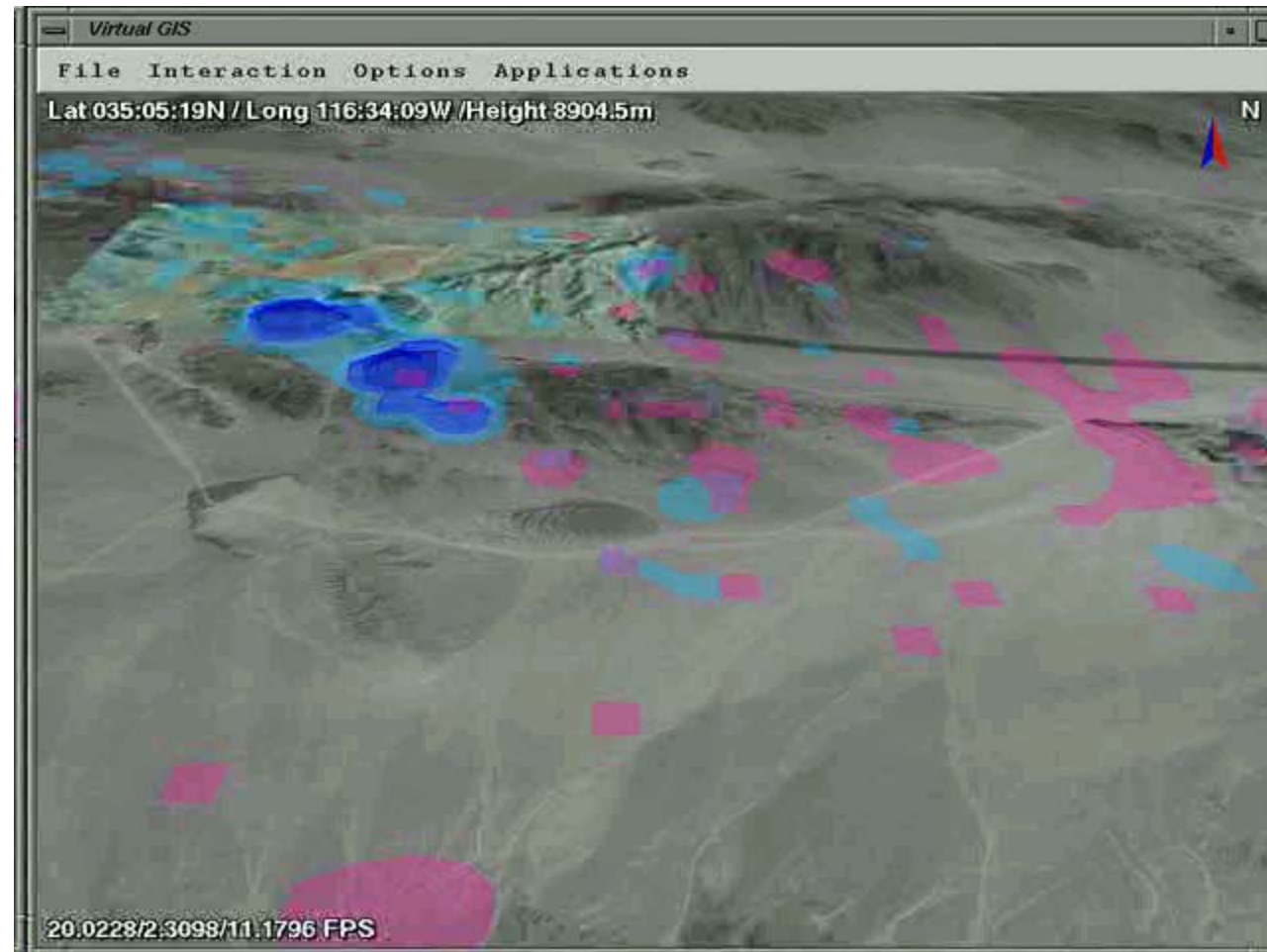


Sharing Understanding





Blobology

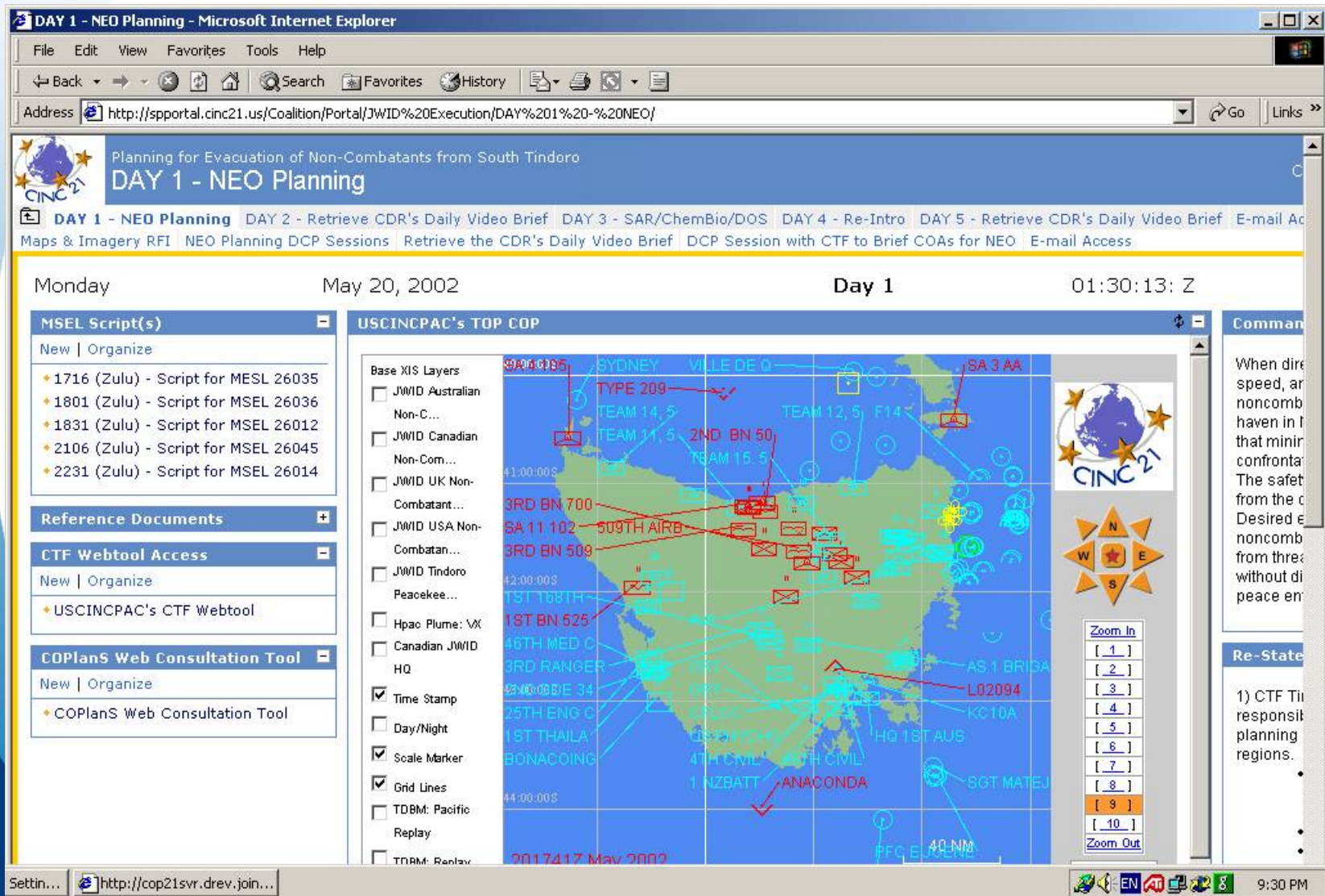




Virtual Reality Workbench

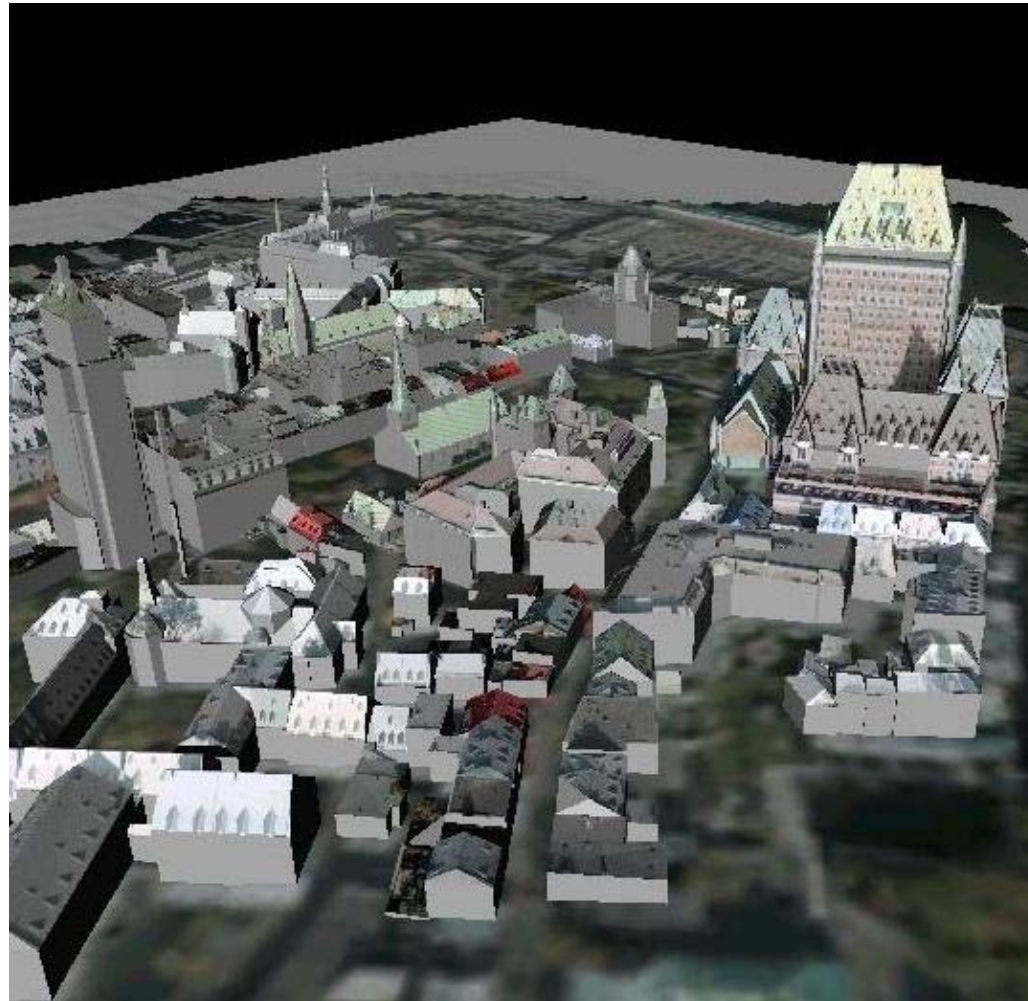


Portal Technology



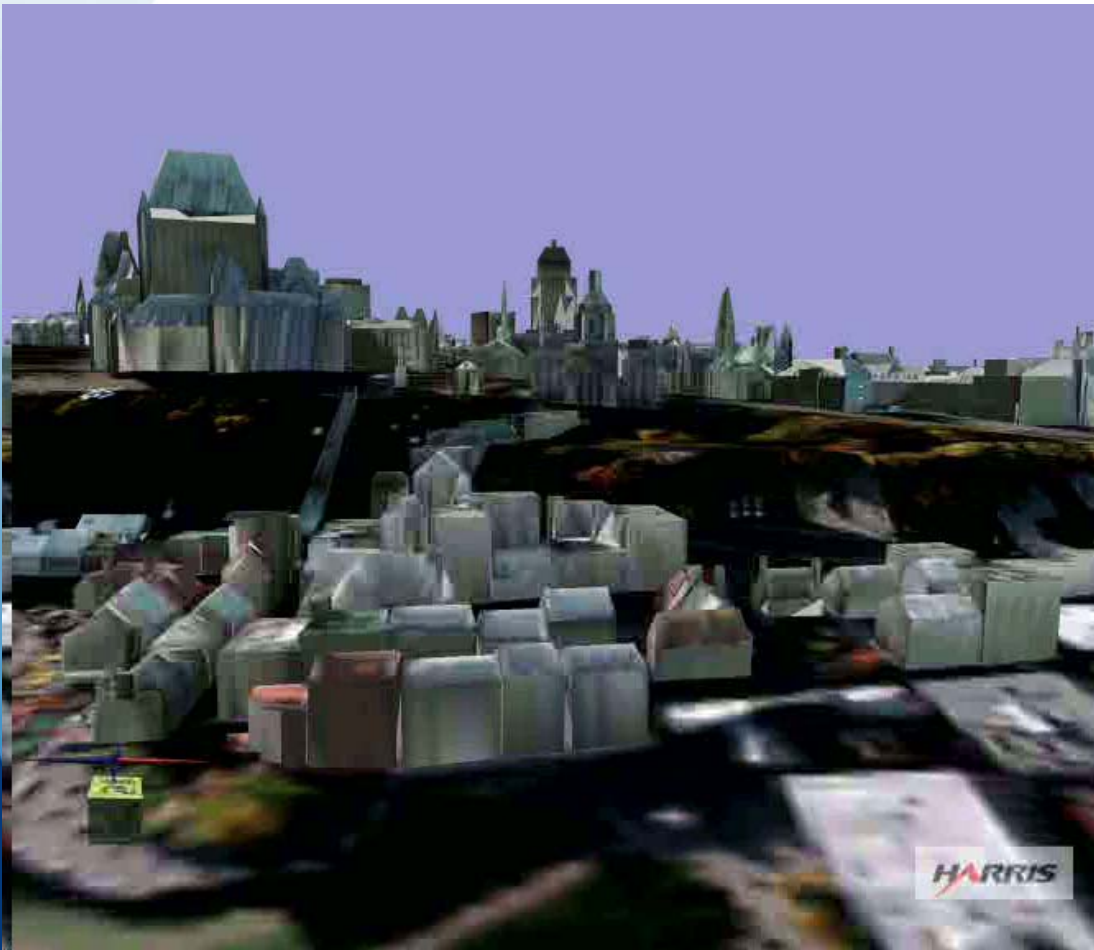


3D Urban Models





3D Urban Modeling Demonstration



Geospatial Correlation for location identification

Capture and production of videos, briefing and annotated imagery

Navigation within the model

Special resource positioning

Mission planning

Performed in Collaboration with **Harris Corporation**



3D Urban Modeling Situation Awareness



Desirable enhancements:

Addition of live video feeds

Modeling of crowd behavior



3D Urban Modeling Photo Realism



Performed in Collaboration
with **Real DB Inc**

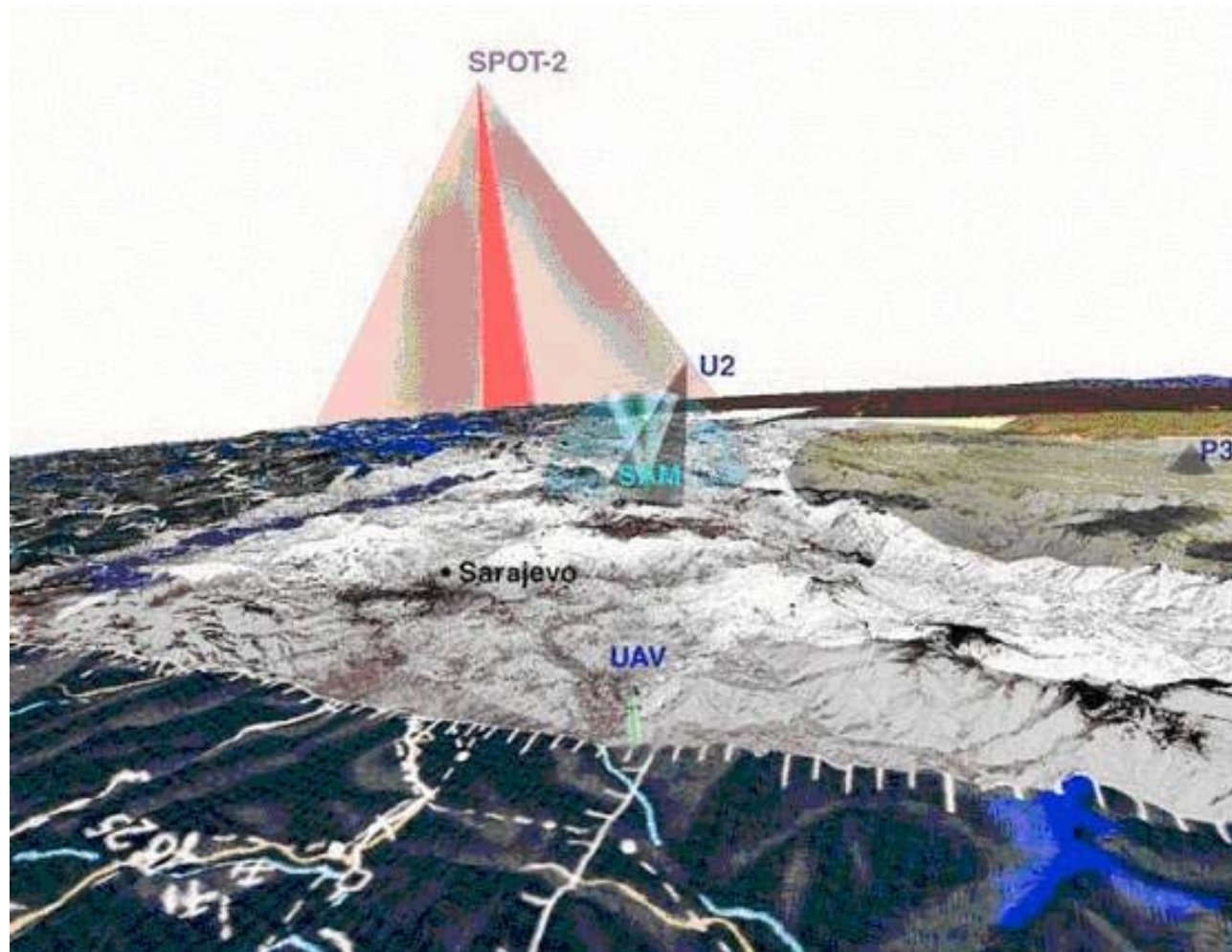


Intelligence Domain

Defence Research & Development Canada

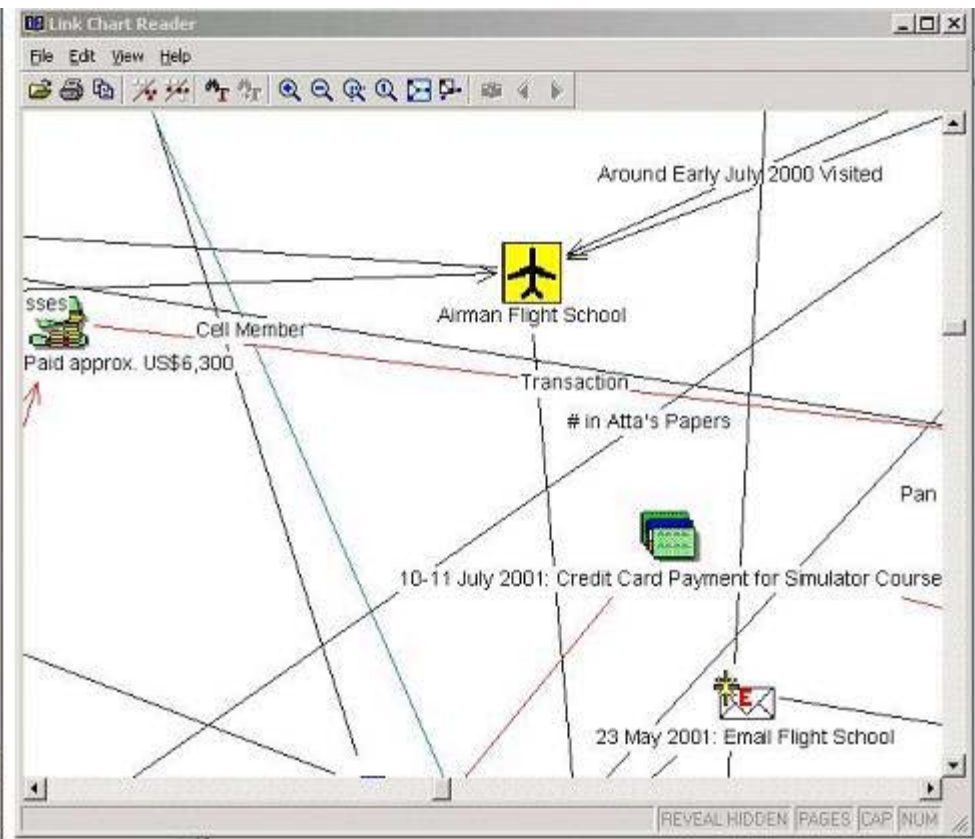
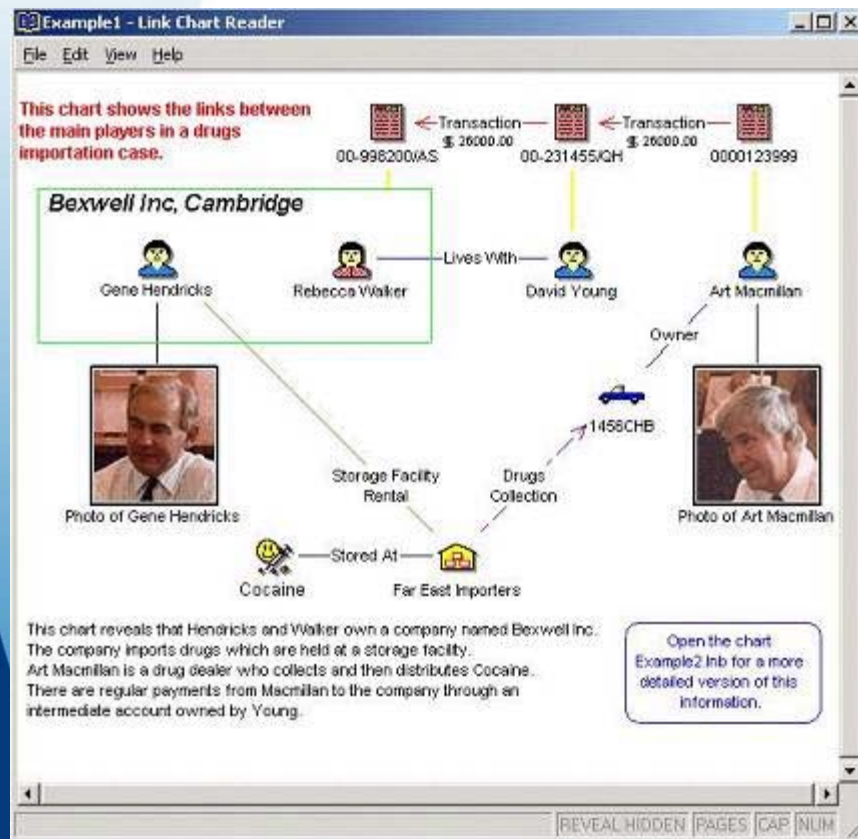


Intelligence, Surveillance & Reconnaissance





Link Analysis

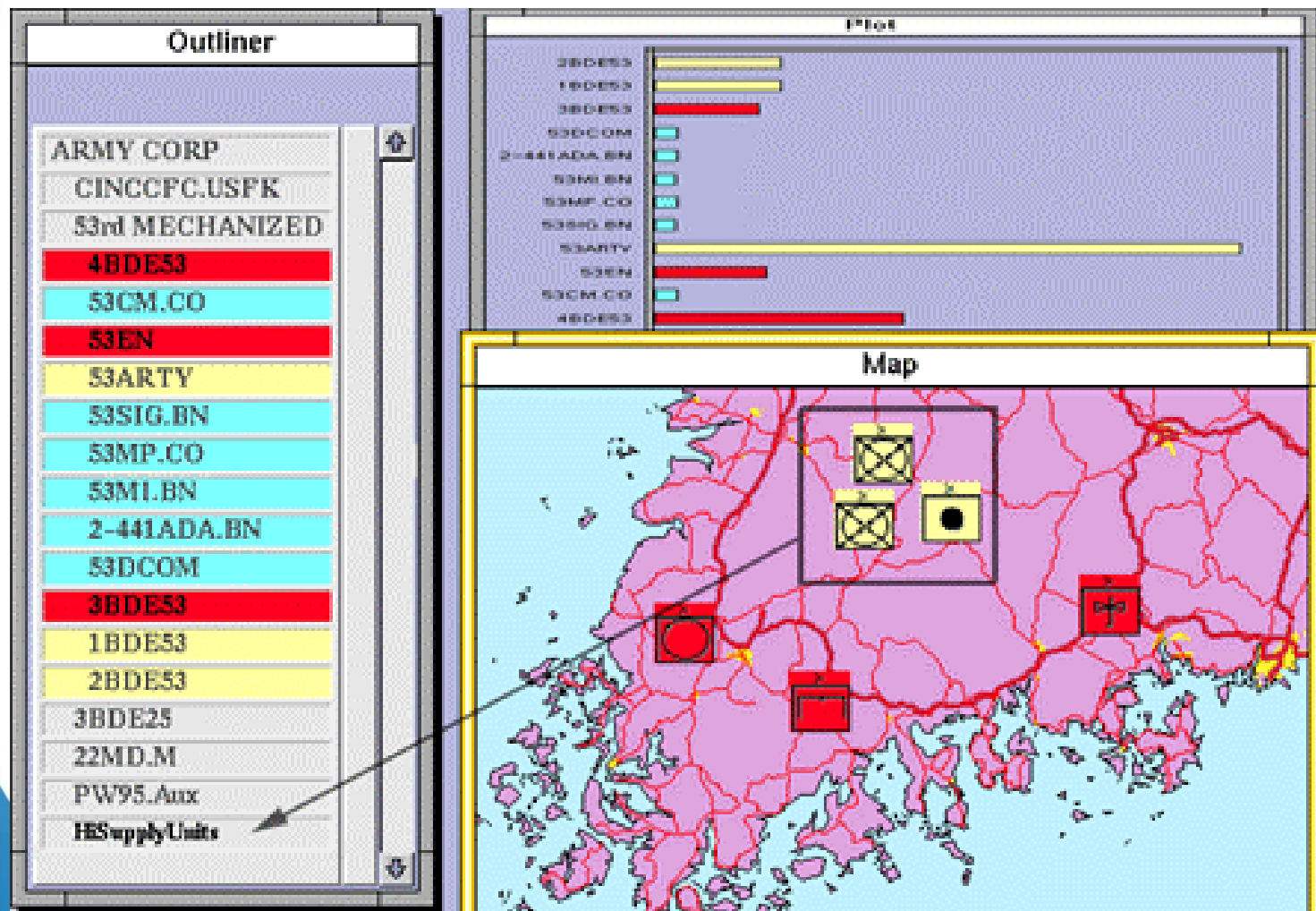




Logistics Domain

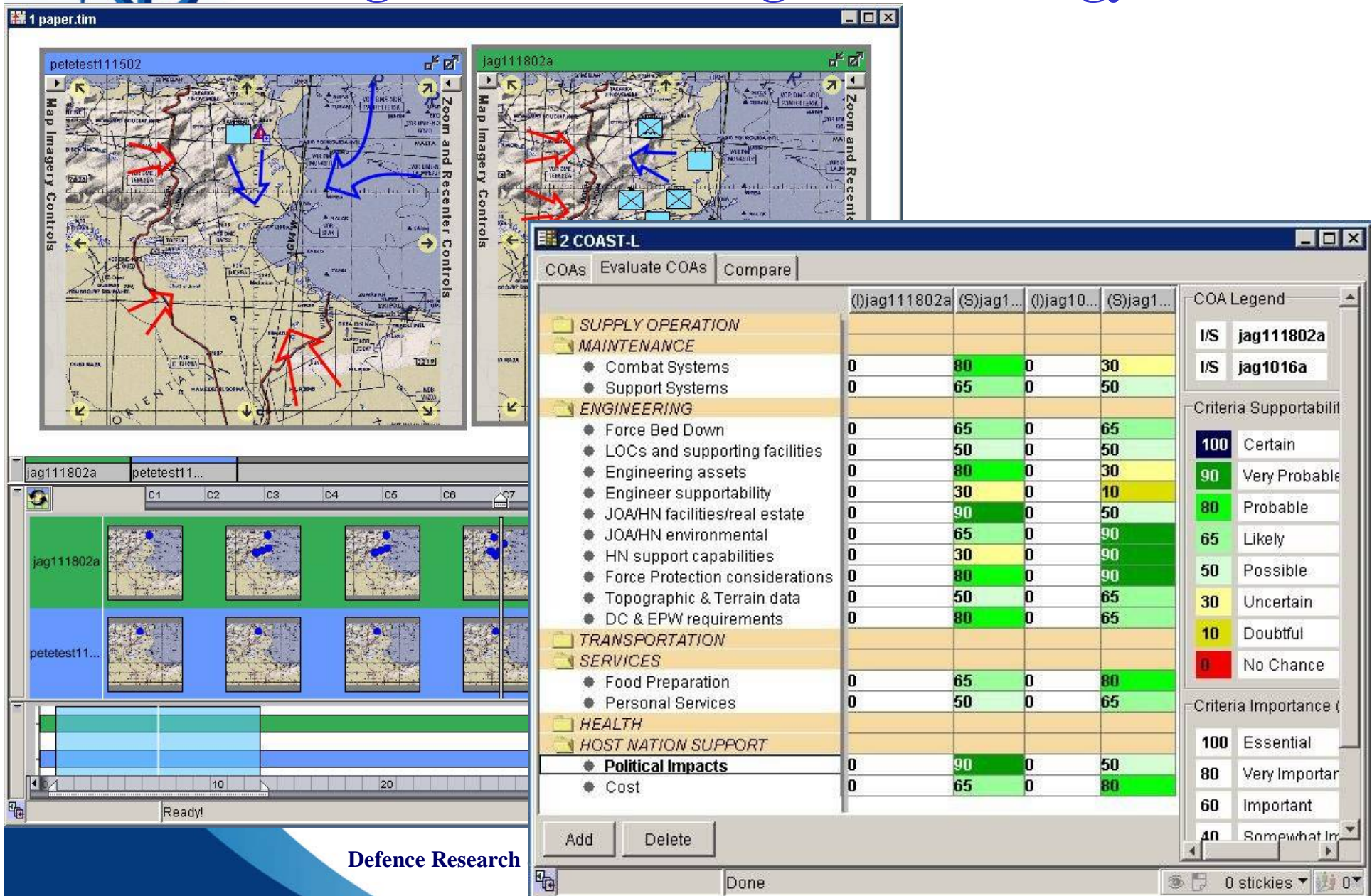


Synchronized Views



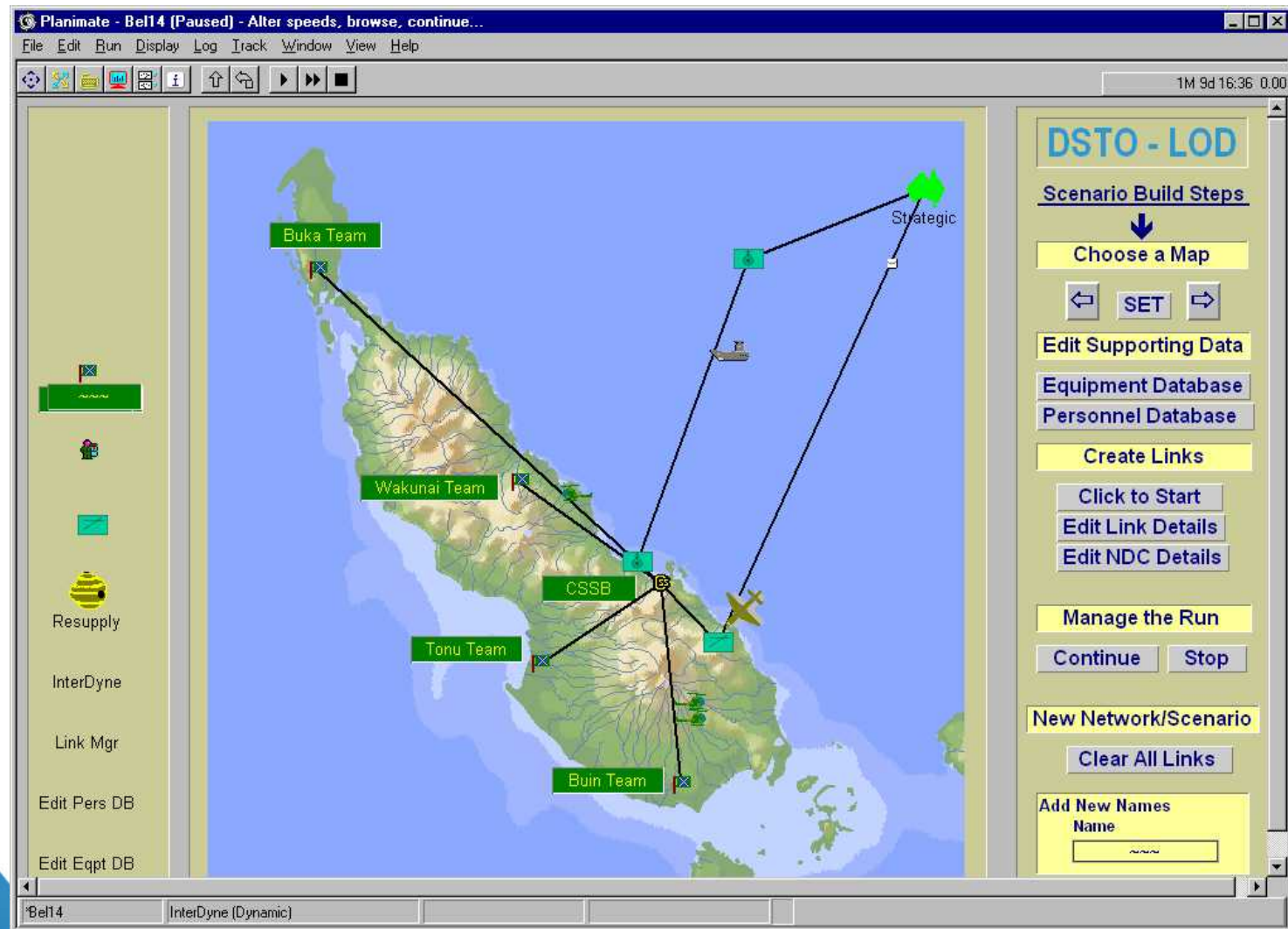


Logistics Views & Agent Technology



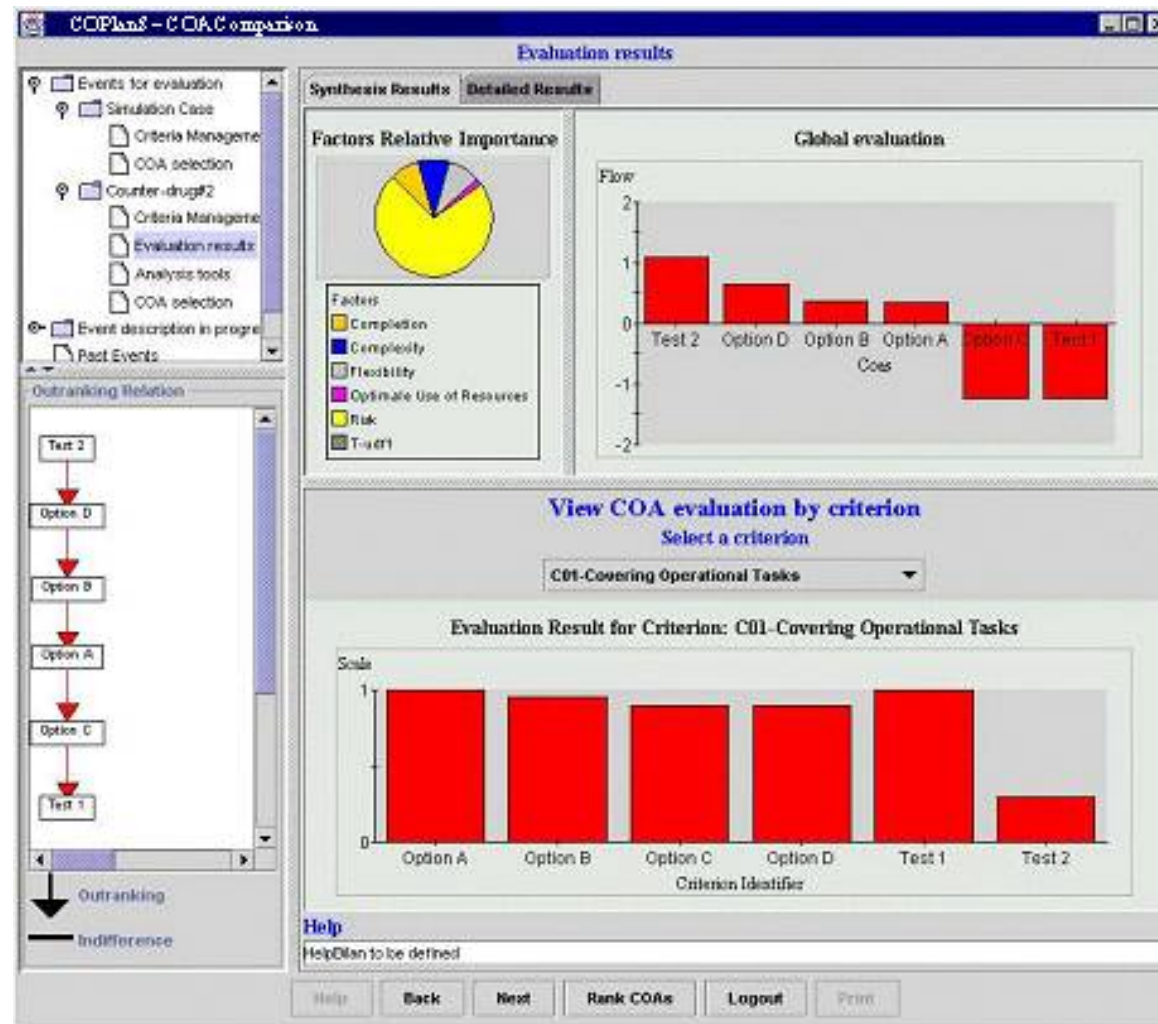


Distorted Logistic View



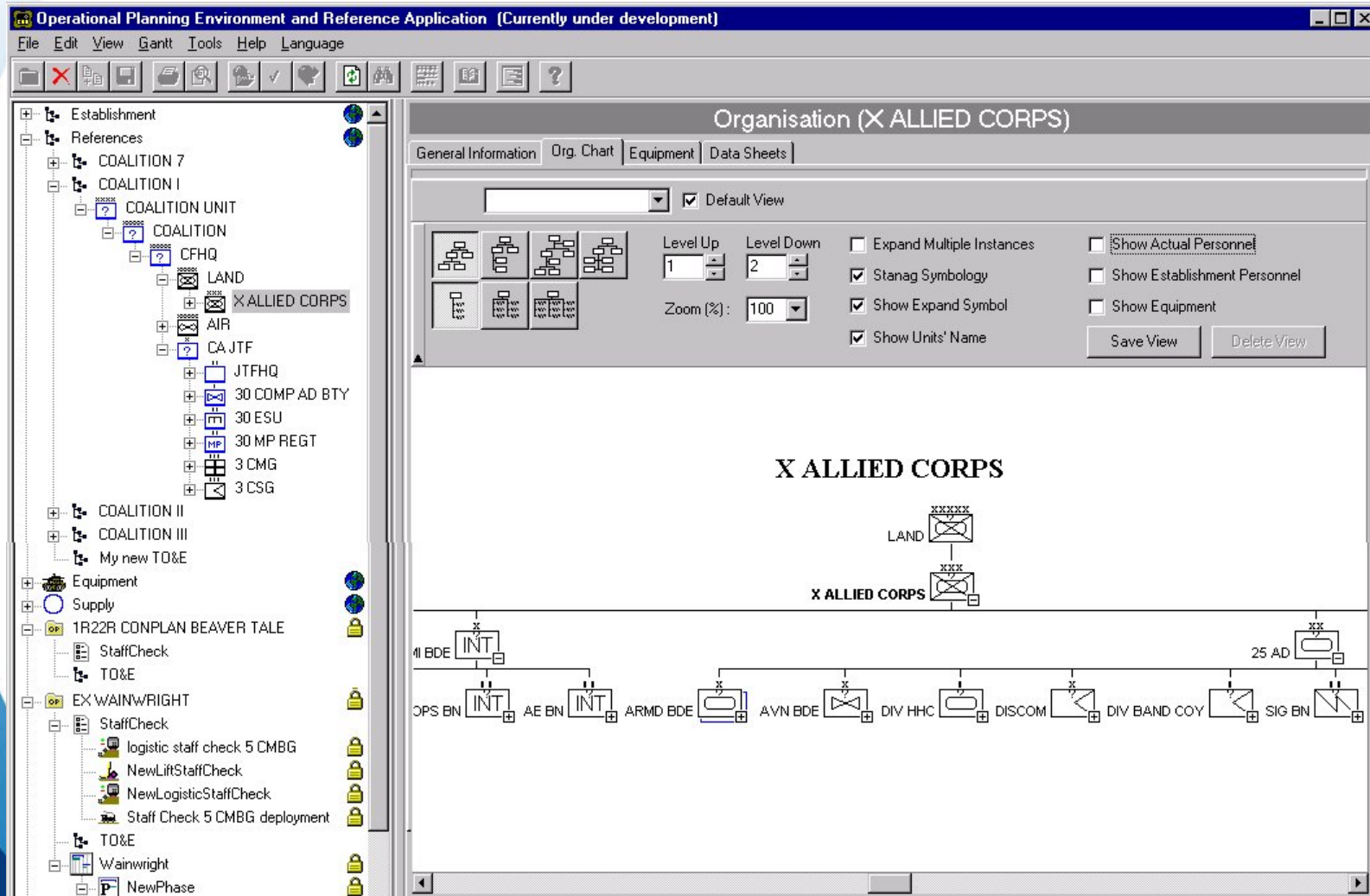


Course of Action Analysis Charts



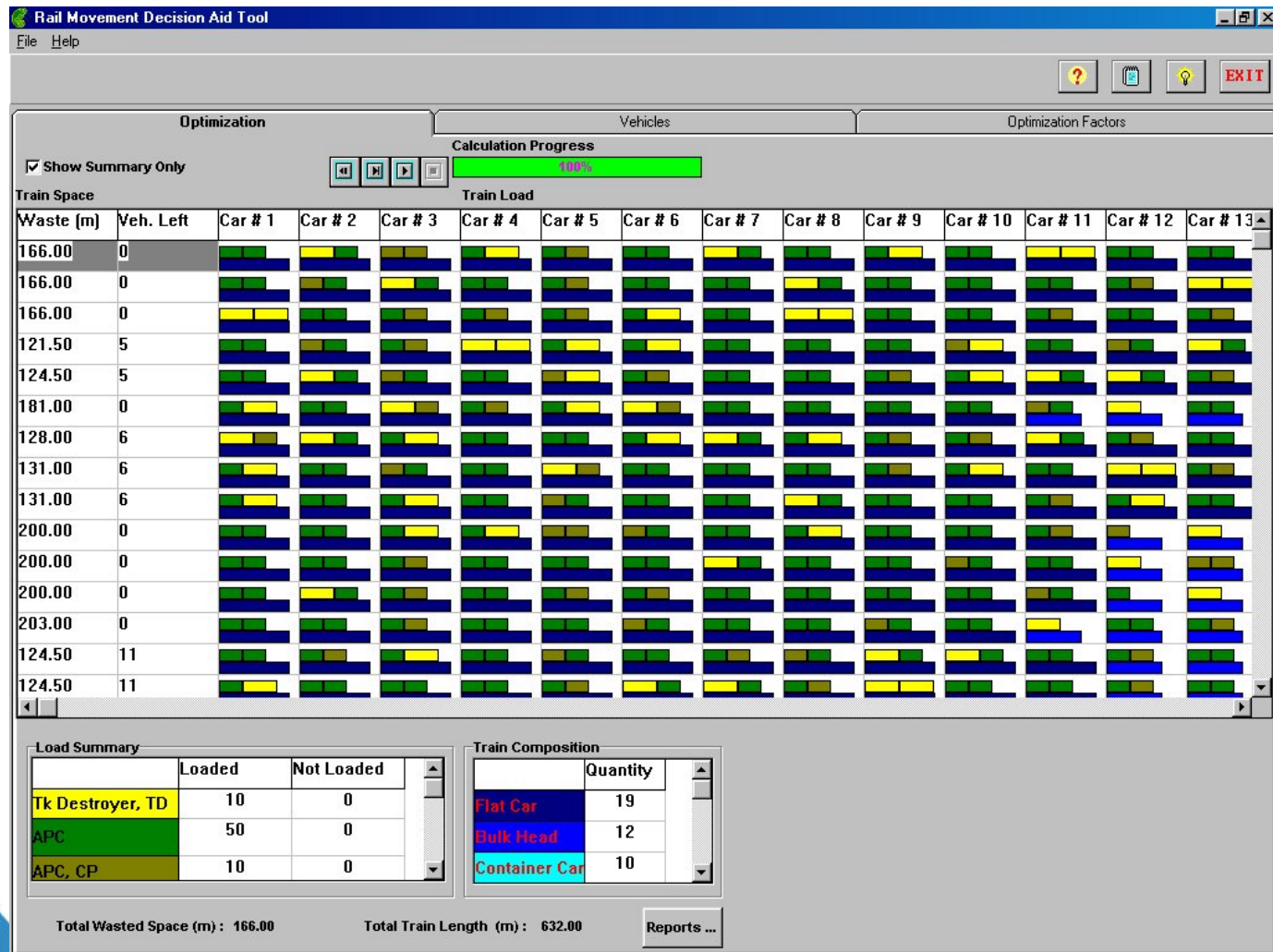


Tree View of Information





Iconic Spreadsheet

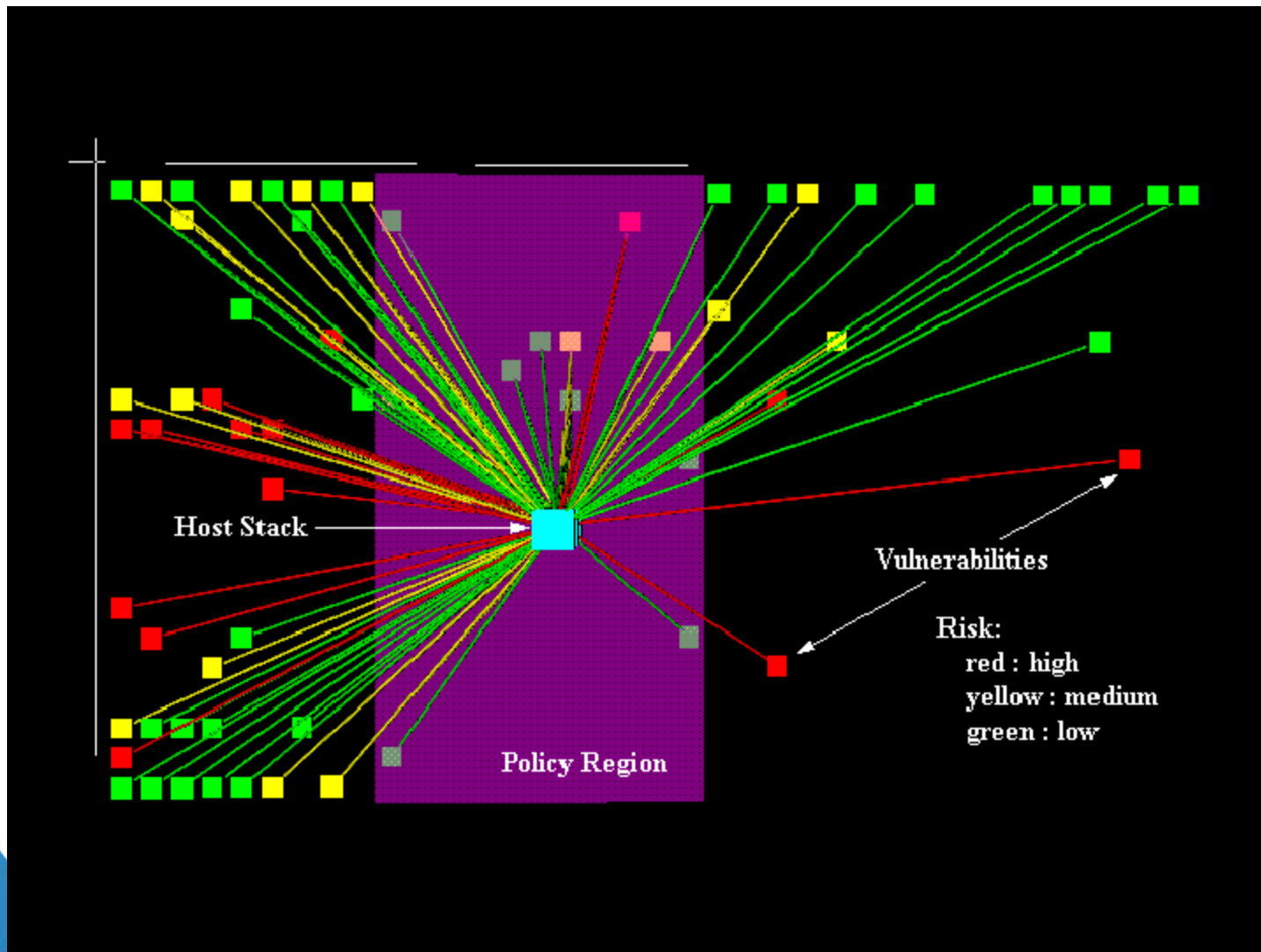




Information Operations Domain



Abstract Representation – Network Vulnerability



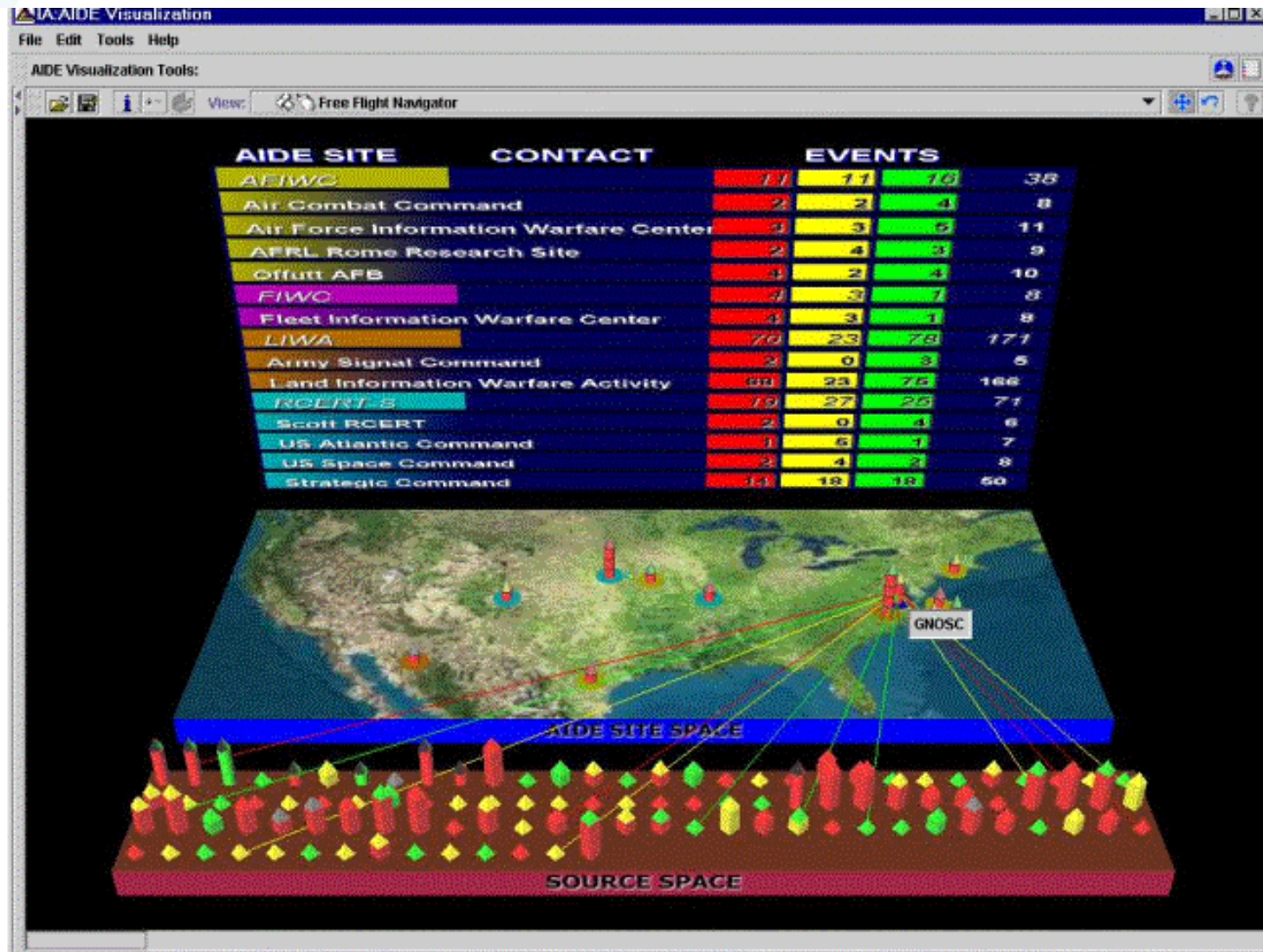


3D Visualization & Agent Technology





Composite View





Discussion / Conclusion (1/3)

- Map-based representations still privileged
 - 2D and 3D with transition
 - Tailoring (info content and map scale)
 - Meaningful symbology
 - Dim map background
 - Temporal information (playback, blobology)
- Non-map based representations
 - Charts (Organizational, 3D, Gantt)
 - Dashboards



Discussion / Conclusion (2/3)

- Human Computer Interface Principles
 - Careful Interface Design (screen real estate, interface widgets)
 - Outline/Tree Views
 - Object Explorer widgets with different visual representations
 - Information Categories using sub-areas and tab folders
 - Multimedia information (video, imagery, alarms)
 - Hyperlinks
 - Multiple views
 - Drag and Drop
 - Animation



Discussion / Conclusion (3/3)

- Trends
 - Collaboration
 - Portal Technology
 - Synchronized views
 - Immersive displays
 - Display devices
 - Abstract Information
 - 3D Urban Models
 - Coalition shared situation awareness